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21 March 2007

Mr. Jonathan S. Davis
Remediation Program Manager
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SUBJECT: AFCEE 4P F41624-03-D-8595; Task Order 0384
MMR SPEIM/LTM/O&M Program
CDRL #A001H
Final Ashumet Pond 2006 Phosphorus Barrier Technical Memorandum

Dear Mr. Davis:

As directed by the Air Force Center for Environmental Excellence, CH2M HILL is hereby distributing copies of the *Final Ashumet Pond 2006 Phosphorus Barrier Technical Memorandum* dated February 2007. Enclosed are six bound copies, one unbound copy and nine compact disc (CD) copies. Copies are also being sent to the appropriate agencies.

Mr. Jon Davis is the Air Force point of contact for this project and can be reached at (508) 968-4670, extension 4952.

Sincerely,

CH2M HILL

Patricia de Groot, P.G., L.S.P.
Program Manager

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337105-SPEIM-ASHPO-TECHMEM-002

Massachusetts Military Reservation

Final Ashumet Pond 2006 Phosphorus Barrier Technical Memorandum

March 2007

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337105-SPEIM-ASHPO-TECHMEM-002

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ACRONYMS AND ABBREVIATIONS

AFCEE	Air Force Center for Environmental Excellence
bpb	below the pond bottom
DO	dissolved oxygen
ft	feet
HMPS	horizontal multiport samplers
kg	kilogram
mg/d	milligrams per day
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MLS	multilevel samplers
MMR	Massachusetts Military Reservation
PVC	polyvinyl chloride
SpC	specific conductance
TDP	total dissolved phosphorus
TM	technical memorandum
USGS	U.S. Geological Survey
WWTP	wastewater treatment plant
ZVI	zero-valent iron

EXECUTIVE SUMMARY

The primary objectives of this technical memorandum are to: (1) present and evaluate the barrier performance data collected by the U.S. Geological Survey (USGS) and the Air Force Center for Environmental Excellence (AFCEE) during 2006; (2) characterize the general geochemical processes that are occurring within the barrier and identify the probable mechanisms of phosphorus removal; and (3) present the barrier monitoring approach for 2007.

Ashumet Pond is a 215-acre kettle pond with a maximum depth of 19 meters (62.3 feet [ft]) and is located near the Massachusetts Military Reservation (MMR) on Cape Cod. The pond is fed primarily by groundwater seepage and has no surface water outlet. A phosphorus-rich groundwater plume, originating from the MMR wastewater treatment plant (WWTP) that operated between 1936 and 1995, has been discharging to Ashumet Pond for more than 20 years. A large mass of easily mobilized phosphorus remains adsorbed to the aquifer matrix between the former WWTP and Ashumet Pond and is expected to continue discharging (in the range of 48 to 110 kilograms [kg] per year) to the pond for decades.

In an effort to address the effects of the phosphorus plume on the trophic state of Ashumet Pond, AFCEE developed the following three-phase remedial strategy: (1) implement a targeted phosphorus inactivation of the pond sediments in the deepest area of the pond to reduce the internal phosphorus load in the pond; (2) install a geochemical barrier within the plume discharge area in the pond to reduce the external phosphorus loading from groundwater seepage; and (3) continue the on-going water quality monitoring program for Ashumet Pond.

Consistent with this strategy, a targeted phosphorus inactivation (alum treatment) of the hypolimnion was conducted in September 2001 using aluminum sulfate and sodium aluminate solutions. A geochemical barrier consisting of zero-valent iron (ZVI) filings mixed with the native sandy shoreline sediments was installed in August 2004 along that part of the shoreline where the highest concentrations of phosphorus are discharging.

The barrier is 300 ft long, approximately three ft thick, and extends approximately 40 ft offshore from the mean shoreline of Ashumet Pond. Barrier performance data collected in 2004 and 2005 indicated that the barrier was effectively removing phosphorus from the targeted part of the plume (AFCEE 2006). During 2006, the USGS collected barrier performance data from a permanent barrier monitoring network and from approximately 200 temporary drive point sampling locations. The 2006 USGS data indicate that phosphorus is being removed from that part of the wastewater plume discharging to the pond through the barrier and that most of the removal is occurring within the interior of the barrier, well before reaching the interface between the barrier and the pond. These data suggest that the barrier is effectively reducing the external phosphorus load to the pond.

In 2006, AFCEE collected general water quality and phosphorus concentration data from five temporary drive point locations within the barrier and sediment data from 13 locations within or in the vicinity of the barrier. The general groundwater chemistry data indicate that highly reducing (e.g., denitrifying, sulfate reducing, and methanogenic) conditions have developed within the interior of the barrier where the majority of the phosphorus removal is occurring. These data suggest that the precipitation of a ferrous iron phase (vivianite) and/or a mixed valent iron-based layered double hydroxide phase (green rust) are the primary mechanisms of phosphorus removal by the barrier. The relatively low levels of phosphorus associated with oxidized iron-rich surface sediment samples of the barrier collected by AFCEE in 2006 support the conclusion that phosphorus is being removed from groundwater within the reducing interior of the barrier and before it can reach, and be adsorbed by, the thin oxidized iron-rich layer at the interface of the barrier and the pond.

1.0 INTRODUCTION

This technical memorandum (TM) presents an evaluation of the performance and chemical characteristics of the Ashumet Pond phosphorus barrier during 2006. It has been prepared under the Air Force Center for Environmental Excellence (AFCEE) Installation Restoration Program, Contract Number F41624-03-D-8595, Task Order 0384, at the Massachusetts Military Reservation (MMR).

The data presented in this report were collected by the U.S. Geological Survey (USGS) and by AFCEE during the summer of 2006. The USGS collected a water quality data set using: (1) a permanent barrier monitoring network (installed in 2004 by the USGS); and (2) approximately 200 temporary drive points installed in 2006 within and in the vicinity of the barrier. Barrier performance data collected by AFCEE in 2006 included water quality data from five temporary drive point locations within the barrier and sediment chemistry data from thirteen surface sediment locations within and outside the barrier footprint. Salient aspects of the AFCEE data and the USGS data are summarized and evaluated in this TM.

1.1 SITE DESCRIPTION AND HISTORY

Ashumet Pond is a 215-acre kettle hole pond located near the MMR on Cape Cod (Figure 1-1). The pond has a maximum depth of about 19 meters (62.3 feet [ft]); it is fed primarily by groundwater seepage and has no surface water outlet. A phosphate-rich groundwater plume (hereafter the phosphorus plume), originating from the MMR wastewater treatment plant (WWTP) that operated between 1936 and 1995, has been discharging to Ashumet Pond for more than 20 years. The section of the pond bottom where the phosphorus plume is discharging is hereafter referred to as the "plume footprint" (Figure 1-2).

Although the discharge of treated wastewater to the aquifer ceased in 1995, a large mass of easily mobilized phosphorus remains adsorbed to the aquifer matrix between the former WWTP and Ashumet Pond (McCobb et al. 2003; Walter et al. 1995). If no

remedial action had been implemented, dissolved phosphorus was expected to continue discharging to the pond (in the range of 48 to 110 kilograms [kg] per year) for decades (McCobb 2003; AFCEE 2002a).

The trophic state of Ashumet Pond has degraded since 1969 when the pond was classified as oligotrophic (K-V Associates 1991). By the mid-1980s, phosphorus loading by the wastewater plume had been identified and the trophic state of the pond was mesotrophic with some early signs of stress (K-V Associates 1991). During the late 1980s and the 1990s the trophic state of the pond gradually declined until it appeared to stabilize near the mesotrophic/meso-eutrophic boundary (AFCEE 2002a). Nevertheless, it has remained a concern that, unless remedial actions were taken, continued loading of excess phosphorus to Ashumet Pond from the wastewater plume would further degrade the trophic health of the pond (Walter et al. 1995; AFCEE 2002a). Consequently, routine trophic health water quality monitoring of Ashumet Pond has been conducted since 1999.

In an effort to address the effects of the phosphorus plume on the trophic state of Ashumet Pond, AFCEE developed a remedial strategy that is outlined in the *Final Ashumet Pond Phosphorus Management Plan* (AFCEE 2001). The strategy consisted of the following three components: (1) reduce the internal phosphorus load by implementing a targeted phosphorus inactivation of the sediments in the deepest section of the pond; (2) install a geochemical barrier within the plume discharge area (i.e., plume footprint) to reduce the external phosphorus loading from groundwater to the pond (Figure 1-2); and (3) continue the ongoing water quality monitoring program for Ashumet Pond.

Consistent with this strategy, a targeted phosphorus inactivation (alum treatment) of the hypolimnion was conducted in September 2001 using aluminum sulfate and sodium aluminate solutions (AFCEE 2002b). A geochemical barrier (the barrier) was installed in August 2004 with the intent to trap phosphorus that otherwise would have discharged into the pond via groundwater.

1.2 BARRIER DESCRIPTION

The barrier consists of three percent (by weight) zero-valent iron (ZVI) filings mixed with native sandy sediments of the pond and it was installed where the highest concentrations of phosphorus in the plume have historically been discharging to the pond (Figure 1-2). The barrier is 300 feet (ft) long, approximately three ft thick, and extends approximately 40 ft offshore from the mean shoreline of Ashumet Pond. Details of the barrier design, installation and the initial phase of barrier performance monitoring (conducted in 2004) can be found in the *Final Ashumet Pond Geochemical Barrier Phosphorus Removal Design Testing & Installation Workplan* (AFCEE 2004) and the *Ashumet Pond Geochemical Barrier for Phosphorus Removal Installation Summary Report* (AFCEE 2005).

1.3 OJECTIVES AND ORGANIZATION

The primary objectives of this TM are to: (1) present the 2006 USGS and AFCEE barrier data and evaluate the performance of the barrier; (2) characterize the general geochemical processes that are occurring within the barrier and identify the probable mechanisms of phosphorus removal; and (3) present the barrier monitoring approach for 2007. The report organization is summarized below.

- Section 1: Introduction
- Section 2: 2006 USGS Barrier Performance Monitoring
- Section 3: AFCEE Barrier Chemistry and Pond Sediment Data
- Section 4: Summary and Conclusions
- Section 5: Future Monitoring
- Section 6: References

2.0 2006 USGS BARRIER PERFORMANCE MONITORING

Between 03 August and 21 August 2006, the USGS conducted a barrier performance monitoring event. The primary objective of this sampling effort was to determine whether the geochemical barrier is continuing to reduce the external phosphorus load (from the former WWTP) to the pond (Figure 1-2). The extent of phosphorus removal by the barrier was evaluated by comparing the phosphorus concentrations in groundwater collected just beneath the barrier to the concentrations of phosphorus in groundwater that has migrated into the middle and upper part of the barrier, prior to discharging to the pond. In order to evaluate the effect of the barrier on the general water quality of the wastewater plume, most barrier performance groundwater samples collected by the USGS were also analyzed for selected field parameters (e.g., dissolved oxygen [DO], pH). These field parameters were also used to identify those barrier samples that were inadvertently diluted with pond water during sample collection, resulting in phosphorus data that are not representative of the actual phosphorus concentrations in the barrier.

A secondary objective of the USGS sampling was to evaluate the effects of the barrier on inorganic nitrogen compounds (e.g., nitrate). A small subset of the groundwater samples that were collected using the permanent monitoring network were also analyzed for ammonium, nitrate, and nitrite. All of the temporary drive point locations were analyzed for ammonium and nitrate.

The sampling methods used by the USGS in 2006 to collect barrier performance data consisted of two general types: (1) groundwater samples and flow rate measurements collected within or near the barrier using five different types of sampling instruments that comprise the permanent USGS barrier monitoring network that was installed within the barrier in 2004; and (2) groundwater samples collected from temporary drive points installed within and adjacent to the barrier.

Data collected by the USGS in 2006 from the permanent monitoring network and from the temporary drive point locations were tabulated, graphed, briefly summarized and submitted to AFCEE in a data summary letter (Appendix A). Some of the 2006 USGS

samples were analyzed for dissolved phosphorus by a USGS laboratory and some were analyzed in the field for orthophosphate using a less precise colorimetric method. The USGS orthophosphate data analyzed by the field colorimetric method are identified in the text as "field phosphate" and are presented in Appendix A as field phosphate expressed as milligrams per liter phosphorus (mg/L P). In 2006 the USGS used both methods to perform duplicate analyses of approximately 200 groundwater samples collected from drive point locations within and adjacent to the barrier. The USGS performed linear regressions of the phosphorus data collected by these two methods. The results indicate that the two methods produce generally comparable results for phosphorus concentrations higher than the 0.24 mg/L detection limit of the field colorimetric method (Appendix B). Details of USGS and AFCEE sampling and analytical methods were previously discussed in the *Final Ashumet Pond 2005 Phosphorus Barrier Technical Memorandum* (AFCEE 2006).

2.1 PERMANENT SAMPLING NETWORK

The USGS permanent monitoring network was installed during barrier construction in 2004 and consists of piezometers, vertical multilevel samplers (MLS), interface diffusion chambers, horizontal multiport samplers (HMPS), and seepage meters (Figure 2-1). Descriptions of the monitoring devices and brief summaries of the USGS data collected from these devices during the 2006 sampling event are presented below. When available, specific conductance (SpC) and DO data for these samples were used to verify that the samples collected near the interface of the barrier and the overlying pond has not been diluted by pond water. Samples collected near the barrier-pond bottom interface that are diluted by pond water commonly show abrupt increases in DO and decreases in SpC relative to undiluted samples collected at the same surface locations but from deeper in the barrier.

2.1.1 Vertical Multilevel Samplers

During barrier construction, eight permanent vertical MLS were installed within the barrier footprint and two (F639P01 and F645P01) were installed outside the barrier as

control locations (Figure 2-1). Each MLS consists of ½-inch diameter polyvinyl chloride (PVC) pipe fitted with five sampling ports at various depths below the pond bottom (bpb) (0.1, 0.8, 1.6, 2.2, and 3.4 ft). The deepest interval (3.4 ft) is positioned to sample ground water below the geochemical barrier. Each port is connected to the surface by a 1/16-inch diameter polyethylene tube. Inside each sampling port, a fiberglass mesh screen is attached to the end of the interior tubing. The top of the sampler is fitted with a 4-inch diameter PVC canister 0.4 ft in length. The purpose of this canister is to hold and protect the sample tubing as well as to protect the sampler top once the device is installed into the barrier.

Results

All ten MLS locations were sampled in August 2006 for the analysis of phosphorus, SpC, and DO by the USGS (Table 1 in Appendix A). Only three of the MLS locations were sampled for the analysis of the nitrogen species (ammonium, nitrate, and nitrite) and pH was measured at one location (Table 1 in Appendix A). Figures 3a through 3j in Appendix A present vertical profiles of the dissolved phosphorus, SpC, and DO data collected from these ten sampling locations in August 2006. Data collected in 2004 and 2005 are also presented for comparison with the 2006 data. Please note that the July 2004 baseline data presented in these figures were collected immediately prior to barrier installation using temporary MLS devices (Table 1 in Appendix A).

The DO and SpC data have been used as indicators of whether any shallow samples collected from the MLS devices had been diluted by pond water during sampling. The abrupt increases in DO and associated decreases in SpC values evident in the shallowest samples (0.1 ft bpb) collected from some MLS locations (e.g., Figure 3a in Appendix A) suggest that the very low phosphorus concentrations in these shallow samples are not representative of in situ barrier conditions and reflect unintended dilution with pond water during sampling. In those locations where there was evidence that pond water had diluted the shallow barrier samples (i.e., in F639P01, F641P01, F642P01, F644P01, F645P01, F646P01, and F647P01), the very low phosphorus concentrations in the shallowest sampling intervals (just below the pond-barrier interface), were not used in the

analysis of barrier performance. As a consequence, barrier performance for these seven locations was based on the changes in phosphorus concentrations between the 3.4 ft sampling interval (just beneath the barrier) and the 0.8 ft interval (0.8 ft bpb).

A review of Figures 3a and 3g in Appendix A indicates that the 2006 phosphorus trends in the two control locations (FSW 639-P01 and FSW 645-P01) showed no notable reduction in the phosphorus concentrations between a sample depth of 3.4 ft and 0.8 ft bpb. Unlike these two control locations, however, there was a general trend toward decreasing phosphorus concentrations with decreasing depth (between 3.4 ft and 0.8 ft bpb) at the eight locations within the barrier footprint. Although the absolute concentrations of dissolved phosphorus detected at these locations have varied between the October 2004, July 2005, and October 2006 sampling events, there has been a consistent general trend toward decreasing phosphorus concentrations at shallower depths during each sampling event since the July 2004 baseline (pre-barrier installation) sampling event.

2.1.2 Vertical Interface Diffusion Samplers

Eight vertical interface diffusion sampling devices (diffusion chambers) were installed during barrier installation in 2004. Of these eight locations, one (DC1-15) was installed south of the barrier and serves as a control location (Figure 2-1). The groundwater diffusion chambers are designed to characterize groundwater at very small vertical intervals (<0.3 ft). The diffusion chamber apparatus consists of a PVC rack containing sampling bottles that is inserted vertically beneath the pond bottom within a hollow four-inch by four-inch square PVC post that is 3.0 ft in length. Each 60-milliliter sampling bottle has a 10-micron diffusion membrane sealing its opening. When placed in the vertical sub-pond bottom rack, the bottles are exposed to the aquifer through portholes in the PVC housing. Each sampler is filled with de-ionized water and allowed to equilibrate with the ambient groundwater. The rack can hold up to 13 sample bottles. To provide time for equilibration, the bottles are typically deployed for two to four weeks prior to sampling. The finished installation at the pond bottom consists of a flush-mounted 4-inch by 4-inch square stainless steel cap.

Results

Diffusion samples collected in August 2006 were analyzed for field phosphate and SpC (Table 2 in Appendix A). Figures 4a, 4b, and 4c in Appendix A present the vertical distribution of the field phosphate and SpC data collected between October 2004 and August 2006 for each of the eight diffusion samplers. A review of these figures indicates that field phosphate concentrations in the diffusion chambers located within the barrier generally decrease with shallower sampling depths in the barrier. Conversely, the field phosphate concentrations observed at the control location (DC1-15) remained relatively high (> 1.0 mg/L) in all of the sampling intervals. These trends have remained relatively consistent at each of these diffusion chamber locations since sampling began in 2004.

Based upon the SpC data presented in Figures 4a, 4b, and 4c in Appendix A, there is no evidence that the field phosphate results collected from the diffusion chambers have been diluted by the infiltration of pond water during sampling. None of the samples collected from the diffusion chambers during August 2006 yielded SpC values that were lower in the shallower samples than in the deeper (high phosphorus) samples. Consequently, the abrupt decreases in phosphorus concentrations observed in the shallower samples collected from the diffusion chambers, are thought to reflect phosphorus attenuation by the barrier.

2.1.3 Horizontal Multiport Samplers

Two horizontal multiport samplers (HMPS) were installed during construction of the geochemical barrier (Figure 2-1). Each HMPS consists of two vertically stacked arrays of PVC pipe extending from the shoreline, pondward across the full width of the barrier. One PVC pipe in each HMPS was buried at a depth of 0.5 ft bpb (near the top of the barrier) and the other pipe in each HMPS is buried at a depth of 3.0 ft bpb (near the bottom of the barrier). Each pipe has an array of 15 sampling ports that are located progressively farther offshore. This design allows horizontal and vertical chemical profiles to be developed across the width of the barrier in both the northern and southern sections of the barrier.

Results

Both HMPS were sampled in August 2006 for SpC, pH, DO, and field phosphate (Table 3 in Appendix A). Figures 5a and 5b in Appendix A present the horizontal and vertical profiles for the SpC, pH, and dissolved phosphorus data collected in 2006. The deeper profiles (collected near the bottom of the barrier) at each HMPS illustrate the phosphorus concentrations, DO concentrations, and the SpC of groundwater just entering the barrier. Ideally, the shallower profiles should reflect changes to these parameters produced during the upward advection of the groundwater through the reactive barrier.

A review of Figures 5a and 5b in Appendix A confirms that there is a general decrease in phosphorus concentrations between a depth of 3.0 ft and 0.5 ft bpb in both the northern and southern HMPS during the August 2006 sampling event. The SpC levels presented in these figures and the DO concentrations in Table 3 of Appendix A were evaluated for indications that contamination with pond water had diluted the phosphorus levels collected from the shallow sampling ports. There were no significant increases in the DO or significant decreases in SpC measurements with sampling depth in either the northern or the southern HMPS in the August 2006 data. The consistency of the DO and SpC data collected from the deeper and shallower intervals suggest that the reductions in the field phosphate concentrations observed in the upper part of the barrier are real, and were not produced by an influx of phosphorus-poor pond water during sampling. Consequently, the overall sampling results for the northern and southern HMPS support the general conclusion that phosphorus is being removed by the barrier.

2.1.4 Deep Pond-Bottom Piezometers

As part of the permanent monitoring network for the barrier, the USGS installed three piezometer clusters in 2004 (locations F633, F635, and F636) in the vicinity of the southern part of the barrier (Figure 2-1). Piezometer cluster (F633) is located at the mean shoreline of the pond, cluster F635 is located 55 ft off shore from the mean shoreline, and cluster F636 is located 110 ft from the mean shoreline (Figure 2-1). Each of these clusters contain four piezometers that extend, respectively, to depths of 10, 30, 60, and 100 ft bpb.

Results

All three of these pond-bottom piezometer clusters were sampled for selected field parameters, dissolved phosphorus, nitrate, and ammonium by the USGS in 2004, 2005, and 2006 (Table 4 in Appendix A). The August 2006 data from the deep piezometer clusters and July 2006 monitoring data from two upgradient multiport monitoring wells (F619 and F621) were used by the USGS to illustrate the vertical distribution of phosphorus, nitrate, and ammonium in groundwater migrating toward and beneath the pond along cross-section line A – A' (Figure 2-1, Figure 2-2, Figure 2-3, and Figure 2-4). Similar to the findings of previous barrier performance evaluations, Figure 2-2, Figure 2-3, and Figure 2-4 suggest that most of the phosphorus-rich groundwater migrating toward the pond will eventually discharge to the pond within the footprint of the barrier while most of the nitrate and ammonium remaining in the WWTP plume is deeper in the aquifer and will discharge farther offshore than the footprint of the barrier. The deeper distribution of nitrate and ammonium relative to the phosphorus is consistent with greater vertical transport of these nitrogen compounds beneath the WWTP during the six decades that it was operating.

2.1.5 Seepage Meters

Eight permanent seepage meters were installed during barrier construction and were designed to enable chemical sampling of groundwater discharging to the pond and the measurement of the rate of discharge (Figure 2-1). Each seepage meter consists of a three-foot-long section of a plastic barrel installed into the barrier until the upper edge was flush with the pond bottom. A plastic top that can be removed or tightly sealed as needed caps each seepage meter. Each seepage meter is 22 inches (55.9 centimeters) in diameter and covers an area of 0.245 square meters. Meters 1a and b are located outside and to the south of the barrier. Paired meters 2a and 2b, 3a and 3b, and 4a and 4b are located in the barrier at varying distances from shore (Figure 2-1).

Results

All of the eight seepage meters were capped on 31 July 2006 and allowed to equilibrate for eight days. After equilibration, the flow rate through each meter was measured four times (Table 5 in Appendix A). Field phosphate was measured in the ground water discharging from each of the meters during at least one of the four flow measurement events. The flow rates and subsequent phosphorus flux rates are presented in Figure 8 of Appendix A.

In general, the highest flow rates were measured in those seepage meters closest to the shoreline. Minimal phosphorus flux (a maximum rate of 7.3 milligrams per day [mg/d]) was measured in the meters located in the barrier area. The control site meters yielded phosphorus fluxes ranging from 154 to 318 mg/d (Table 5 in Appendix A). The lower phosphorus fluxes observed in the seepage meters installed in the barrier relative to the control seepage meters indicate that a large amount of the plume-related phosphorus load is being removed by the barrier. However, given the significant spatial variation in the flux rates of water through the barrier and the limited number of seepage meters that are installed, there are insufficient seepage meter data to reliably estimate the total mass of phosphorus being removed by the barrier.

2.2 TEMPORARY DRIVE POINT SAMPLING

During August 2006, the USGS collected approximately 200 temporary drive point samples at 76 locations to delineate the current distribution of phosphorus, inorganic nitrogen, and/or selected field parameters in ground water at 0.5, 1.5, and 3.0 ft bpb within or in the vicinity of the geochemical barrier (Figure 2-5). Installation information for these temporary drive points is presented in Table 6 of Appendix A. The field parameters and chemical data collected from these locations are presented in Table 7 of Appendix A.

The data collected at these drive point sampling locations were used by the USGS to produce digitized and colorized contour maps for the concentrations or values of the parameters of interest at each of the three sampling depth intervals (0.5, 1.5, 3.0 ft bpb). These contour maps and a location map for the drive points are incorporated in the 2006

USGS data summary letter (Figures 9a through 9i of Appendix A). For the convenience of the reader, a drive point location map and the relevant contour maps presented in Appendix A are also presented as Figure 2-5, Figure 2-6, Figure 2-7, Figure 2-8, Figure 2-9, Figure 2-10, Figure 2-11, and Figure 2-12 of this TM.

2.2.1 Phosphorus

As previously discussed, achieving a notable reduction in the external phosphorus load to the pond is the primary remedial objective of the geochemical barrier. The barrier was located within that section of the plume footprint on the pond bottom where the most phosphorus-rich wastewater in the plume has historically been discharging (Figure 1-2).

Results

The elevated levels of phosphorus present in groundwater beneath the barrier (3.0 ft bpb) are not present within the barrier at a sampling depth of 0.5 ft bpb (Figure 2-6). Conversely, elevated phosphorus concentrations remain at the 0.5 ft bpb sampling interval within a thin zone of the pond bottom located between the shoreline and the near-shore edge of the barrier (Figure 2-6). The extent of this thin zone as presented in Figure 2-6, was further defined by the collection of field phosphate data from additional shallow (0.5 ft bpb) drive points installed between the shoreline and the near-shore edge of the barrier (Figures 9a and 9f of Appendix A). This thin zone of elevated phosphorus concentrations corresponds to that portion of the phosphorus plume that is discharging to the pond between the barrier and the shoreline. Figure 2-6 illustrates that the phosphorus concentrations in the wastewater plume discharging to the pond within the footprint of the barrier have been reduced by the barrier relative to the phosphorus concentrations in the wastewater plume discharging to the pond outside of the barrier footprint.

The average phosphorus concentrations in samples collected within the phosphorus plume discharge area of the pond and within the footprint of the barrier at depths of 3.0 ft (just below the barrier) and 0.5 ft bpb (near the top of the barrier) were calculated for 37 drive point surface locations (Appendix C). This procedure was repeated for the 3.0 and 0.5 ft bpb samples collected from thirty surface locations within the discharge area of the phosphorus plume but outside the footprint of the barrier (Appendix C). The

average phosphorus concentrations in the 37 samples collected beneath the barrier (3.0 ft bpb) and near the top of the barrier (0.5 ft bpb) were calculated to be 0.89 mg/L and 0.12 mg/L respectively, a reduction of approximately 87 percent of the phosphorus concentrations entering the barrier. Conversely, the average phosphorus concentrations for the 3.0 ft bpb and 0.5 ft bpb samples collected outside the barrier but within the footprint of the plume were 0.64 mg/L and 0.60 mg/L respectively, indicating essentially no reduction in phosphorus concentrations with decreasing depth. The higher absolute concentrations observed beneath the barrier at a depth of 3.0 ft bpb relative to the concentrations observed at 3.0 ft bpb outside the footprint of the barrier, reflects the fact that the barrier was installed within that part of the plume discharge area where the highest phosphorus values have historically been observed.

2.2.2 Inorganic Nitrogen (Nitrate and Ammonium)

A detailed trophic health investigation of Ashumet Pond conducted in 1999 found that Ashumet Pond was phosphorus limited over most of the growing season (AFCEE 2002a). Nevertheless, a high external load of inorganic nitrogen compounds (e.g., nitrate and ammonium) can be an important driver for cultural eutrophication processes in many freshwater and saltwater systems. For this reason, the potential of the geochemical barrier to reduce nitrogen concentrations in groundwater prior to discharging to the pond was evaluated and the concentrations of nitrate and ammonium in the groundwater within or in the vicinity of the barrier at depths of 0.5, 1.5, and 3.0 ft bpb are presented in Figure 2-7 and Figure 2-8.

Results

Most of the inorganic nitrogen (e.g., nitrate and ammonium) in the wastewater plume is discharging to the pond farther offshore than the footprint of the barrier (Figure 2-3, Figure 2-4, Figure 2-7, and Figure 2-8). The highest concentrations of nitrate (>2.0 mg/L) detected by the network of temporary drive points were located just to the southeast of the outside edge of the barrier (Figure 2-7). Moderately elevated concentrations of nitrate were observed to extend beneath part of the barrier at a depth of 3.0 ft bpb. However, these moderately elevated nitrate concentrations were not present in

shallower samples (e.g., at a depth of 0.5 ft bpb) collected from the interior of the barrier at the same surface locations. Conversely, much of the elevated nitrate concentrations observed outside the footprint of the barrier at a depth of 3.0 ft bpb remain present at a depth 0.5 ft bpb. This contrast in the distribution of nitrate with decreasing depth within the barrier relative to outside the barrier, indicates that the barrier is removing nitrate from groundwater (Figure 2-7). The observed nitrate removal is likely related to the conversion of nitrate in the groundwater to nitrogen gas (N_2) by denitrifying bacteria that have become established within the barrier.

Figure 2-8 illustrates the distribution of ammonium within and in the vicinity of the barrier footprint. As with nitrate, the highest concentrations of ammonium are located outside the barrier footprint and moderately elevated concentrations are present beneath the barrier footprint at a depth of 3.0 ft bpb. Unlike nitrate, the moderately elevated levels of ammonium within the footprint of the barrier do not notably decrease at shallower depths (i.e., within the barrier), indicating that most of the ammonium is not being removed from groundwater by the barrier.

2.2.3 Physico-Chemical (Field) Parameters

Changes in groundwater SpC, DO, pH, and temperature in degrees centigrade with depth bpb within and in the vicinity of the barrier footprint are presented in Table 7 of Appendix A and in Figure 2-9, Figure 2-10, Figure 2-11, and Figure 2-12. A review of Table 7 of Appendix A and Figure 2-9, Figure 2-10, Figure 2-11, and Figure 2-12 indicate that the SpC and pH of groundwater increase as the groundwater migrates upward into, and interacts with, the barrier. DO concentrations in groundwater located just below the barrier are generally low (commonly 1.0 mg/L or less), owing to microbial processes in the wastewater-contaminated aquifer. Once the groundwater enters the barrier, these low DO concentrations are generally reduced to nondetect (< 0.1 mg/L) or near nondetect levels (Figure 2-10, and Table 7 in Appendix A). Although the temperature of the groundwater increases between 3.0 and 0.5 ft bpb, this change in groundwater temperature is not limited to the area of the barrier footprint. The observed increases in temperature likely reflect the ability of shallow surface water to warm very shallow groundwater during the summer months.

3.0 AFCEE BARRIER CHEMISTRY AND POND SEDIMENT DATA

Between 03 October and 05 October 2006, AFCEE collected groundwater from two depth intervals (mid-screen depths of 0.8 ft and 4.0 ft bpb) at each of five temporary drive point surface locations positioned within the barrier footprint and from two background locations positioned outside the barrier footprint (Table 3-1; Figure 3-1). Groundwater quality data that was collected by AFCEE in 2005 from a third location outside the barrier footprint (95DPB0225) has also been included in Table 3-1. In addition to the groundwater samples described above, AFCEE also collected surface sediment samples from six locations within the barrier and from seven locations outside of the barrier footprint (Figure 3-1). Groundwater samples from the seven temporary drive point locations were analyzed for up to 15 groundwater quality parameters (Table 3-1) and the 13 sediment samples were analyzed for total iron, total phosphorus and total manganese concentrations (Table 3-2). These data were collected to identify the general geochemical changes in the wastewater-contaminated groundwater after it enters the barrier and to identify the probable mechanisms of phosphorus removal by the barrier.

3.1 GROUNDWATER QUALITY RESULTS

The changes to the general chemistry of groundwater migrating through the barrier have been evaluated by comparing the chemistry of the groundwater collected from within the barrier to the chemistry of groundwater collected from beneath the barrier and from three background locations outside the barrier footprint (Table 3-1). The data presented in Table 3-1 indicate that the general chemistry of the wastewater-contaminated groundwater water collected from inside the barrier (mid-screen depth of 0.8 ft bpb) is chemically distinct from groundwater collected beneath the barrier (mid-screen depth of 4 ft bpb) and from groundwater collected at the three background locations. Generally, the concentrations of dissolved iron, methane and alkalinity are higher within the barrier while the concentrations of dissolved sulfate and nitrate are much lower relative to samples collected beneath the barrier or from locations outside the barrier footprint. These changes in the groundwater chemistry are consistent with the development of highly reducing conditions and suggest that populations of denitrifying, sulfate reducing,

and methanogenic bacteria have developed within the barrier. The calcium and magnesium concentrations in the groundwater collected just beneath the barrier and within the upper foot of the barrier are not notably different (Table 3-1). This suggests that precipitation of calcium carbonate within the barrier is minimal, despite the higher alkalinity and pH conditions that have developed within parts of the barrier (Table 3-1; Figure 2-11). Consequently, precipitation of calcium carbonate does not appear to be contributing to a reduction in the permeability of the barrier as has been observed to occur in some other ZVI barriers (Furukawa et al. 2002; Li et al. 2005).

The shallow sample (0.8 ft bpb) collected from background location 95DP3008 shows many of the same depth-related changes in chemical characteristics (e.g., increased iron and methane and decreased sulfate concentrations) that were observed in the shallow samples collected from the locations within the barrier footprint (Table 3-1). Furthermore, background location 95DP3008 is the only location sampled in 2006 that shows a notable reduction in the concentrations of calcium and magnesium (suggesting calcium carbonate precipitation) between a mid-screen depth of 4.0 and 0.8 ft bpb (Table 3-1). The proximity of this background location to the barrier footprint (Figure 3-1) suggests that the groundwater collected at 0.8 ft bpb at 95DP3008 has been affected by the close proximity of the barrier and that it is not representative of true background conditions.

3.2 POTENTIAL PHOSPHORUS REMOVAL MECHANISMS

The concentrations of total dissolved phosphorus (TDP) in the AFCEE groundwater samples collected within the barrier are notably lower than the concentrations in samples collected immediately below the barrier (Table 3-1). These data are consistent with the 2006 USGS barrier performance data (Figure 2-6; Appendix A) and further support the inference that phosphorus removal is occurring within the barrier.

Unaltered ZVI has little or no direct capability to adsorb or otherwise remove dissolved phosphorus (phosphate) from groundwater. When ZVI is exposed to oxygenated groundwater or surface water, however, it will be oxidized by oxygen to the ferric (3^+)

state, resulting in the precipitation of ferrihydrite ($Fe(OH)_3$) or other highly insoluble ferric hydroxide compounds with a high affinity and sorption capacity for dissolved phosphorus (Clayton et al. 2004**)**. Under anoxic conditions, ZVI will react with water resulting in the production of hydrogen gas by the reduction of water and of ferrous (2^+) iron by the oxidation of the ZVI. Ferric iron is not stable in such a highly reducing anoxic system and consequently, ferric hydroxides are unlikely to precipitate.

As previously discussed, most of the phosphorus-rich groundwater entering the bottom of the Ashumet Pond ZVI barrier contains DO concentrations of only about 1.0 mg/L or less and the groundwater appears to be deoxygenated very rapidly upon reaching the barrier. Groundwater samples collected in 2006 (Table 3-1) confirm that highly reducing (methanogenic and sulfate reducing) conditions are present in the interior of the barrier. Given the existence of such highly reducing conditions within the barrier, ferric hydroxides, or other fully-oxidized iron compounds are unlikely to be a major component of the corrosion assemblage that has developed. Consequently, sorption of phosphorus by ferric iron hydroxides is probably not a significant mechanism of phosphorus removal in the interior of the barrier. Rather, the highly reducing conditions and elevated concentrations of ferrous iron in the barrier suggest that the precipitation of vivianite ($Fe_3(PO_4)_2.8H_2O$) may be producing the observed reductions in phosphorus concentrations within the barrier. Vivianite is known to form in phosphorus and iron rich sediments under anaerobic conditions (Hearn et al. 1983; Emerson and Widmar 1978) and it has been observed to precipitate on the surfaces of mild (unalloyed) steel during laboratory investigations of microbially-mediated corrosion reactions (Volkland et al. 2000) and on the surfaces of ZVI in column studies where the influent contained elevated concentrations of dissolved phosphate (Wust et al. 1998). Phosphorus removal within the barrier may also reflect the formation of green rust, a layered, anion exchanging Fe(II)–Fe(III)–double hydroxide that is a common corrosion product in ZVI barriers (Furukawa et al. 2002). Green rust is known to sorb phosphate and ultimately to facilitate the formation of vivianite in ferrous iron-rich systems (Hansen and Poulsen 1999).

3.3 SEDIMENT RESULTS

As part of the October 2006 sampling event, AFCEE collected six surface sediment samples (generally the top inch of sediment) from within the barrier footprint and from seven locations located northeast and southwest of the barrier (Figure 3-1). Five of the six sediment samples collected within the barrier footprint were collected at the five AFCEE drive point locations discussed in Section 3.1 (Figure 3-1). During collection, all samples were screened with a number 4 mesh screen to remove all material coarser than 4.75 millimeters and analyzed for total iron, total manganese and total phosphorus (Table 3-2). The sediment data were used to: (1) determine whether the oxidized iron-rich surface layer of the barrier is sequestering phosphorus; (2) evaluate the extent that iron-rich sediments have migrated outside the footprint of the barrier.

Surface sediment samples collected inside the barrier footprint (Figure 3-1; Table 3-2) consisted of a mixture of gravelly, fine- to coarse-grained dark brown to gray colored sand with a patina of reddish brown oxidized iron at the interface with the overlying pond water. Surface sediment samples collected outside of the barrier footprint consisted of variable mixtures of gravelly, fine- to coarse-grained reddish-brown to tan colored sand. Iron concentrations in the six barrier sediment samples were much higher than the samples collected outside the barrier and ranged from 23,000 to 130,000 milligrams per kilogram (mg/kg). The iron concentrations in the four samples collected south of the barrier footprint ranged from 380 to 4,700 mg/kg and the three samples collected north of the barrier footprint ranged from 2,100 to 18,000 mg/kg (Table 3-2). Only two sample locations (95SE0016 and 95SE0017) outside the barrier contained iron concentrations that were notably higher than the average iron concentrations (2,126 mg/kg) from ten shallow sediment samples (0 to 1 foot bpb) collected from the area prior to installation of the barrier (AFCEE 2005). Both of the northern samples with elevated iron concentrations were located within 100 ft of the northern edge of the barrier (Figure 3-1). Comparison of the iron concentrations in those samples collected inside the barrier footprint to those collected outside the barrier footprint suggests that long shore transport of iron hydroxide coated sand outside the barrier footprint has been relatively limited since barrier installation in 2004.

The very low total phosphorus concentrations in the surface sediments collected within the footprint of the barrier (95SE0009 through 95SE3015) are consistent with the 2006 USGS and AFCEE drive point data that indicate that most phosphorus in the groundwater beneath the barrier footprint is removed prior to reaching the upper few inches of the barrier. Conversely, the two samples collected north of the barrier footprint that contained relatively elevated iron concentrations (95SE0016 and 95SE0017), also contained the highest phosphorus concentrations detected in any of the samples collected in or out of the barrier footprint. The elevated levels of phosphorus in these two locations suggests that the oxidized iron-coated sand transported outside of the barrier footprint but still within the phosphorus plume discharge area, has continued to remove phosphorus from discharging groundwater or possibly from the overlying pond surface water.

4.0 SUMMARY AND CONCLUSIONS

The 2006 barrier performance data collected from the USGS permanent monitoring network and from approximately 200 temporary drive point locations indicate that the barrier is continuing to effectively remove phosphorus from that part of the wastewater plume discharging to the pond through the barrier footprint and thus, reducing the external phosphorus load to the pond.

Most of the inorganic nitrogen (e.g., nitrate and ammonium) in the wastewater plume is discharging to the pond farther offshore than the footprint of the barrier. Nevertheless, Figure 2-7 indicates that moderately elevated concentrations of nitrate were observed in drive point samples collected from beneath (i.e., 3.0 ft bpb) part of the barrier. The moderately elevated concentrations of nitrate in groundwater immediately beneath the barrier were reduced to essentially non detectable concentrations in groundwater that had migrated into the barrier. Conversely, Figure 2-7 suggests that much of the elevated nitrate concentrations observed outside the footprint of the barrier at a depth of 3.0 ft bpb largely remained present at a depth 0.5 ft bpb. This contrast in the vertical distribution of nitrate within the footprint of the barrier relative to outside the barrier, suggests that a population of denitrifying bacteria has developed within the barrier and is converting nitrate in the groundwater passing through the barrier to nitrogen gas (N_2). Unlike nitrate, the moderately elevated levels of ammonium beneath the barrier do not notably decrease at shallower depths (i.e., after entering the barrier).

Changes in groundwater SpC, pH, DO, and temperature with depth bpb within and in the vicinity of the barrier footprint were examined. The data indicate that SpC and pH generally increase as the groundwater migrates upward into the barrier while DO concentrations typically decline to nondetect (< 0.1 mg/L) or near nondetect levels. The temperature of the groundwater increases between 3.0 and 0.5 ft bpb. However, this change in groundwater temperature is not limited to the area of the barrier footprint and is attributed to conductive warming of very shallow groundwater during the summer by the proximity of warm surface water.

Groundwater samples collected in 2006 confirm that sulfate reducing and methanogenic conditions are present in the interior of the barrier. Such highly reducing conditions within the barrier suggest that ferric hydroxides are probably not a major component of the corrosion assemblage and sorption of phosphorus by ferric iron hydroxides is probably not a significant mechanism of phosphorus removal in the barrier. Rather, the highly reducing conditions and elevated concentrations of dissolved iron in the barrier suggest that the formation of the ferrous iron phosphate mineral vivianite ($Fe_3(PO_4)_2.8H_2O$) and/or green rust may be the primary phosphorus removal mechanisms within the barrier.

Low levels of phosphorus in the oxidized iron-rich surficial sediment collected within the barrier footprint support the conclusion that phosphorus is being removed from groundwater before it reaches the top of the barrier and discharges to the overlying pond. The elevated iron concentrations present in the upper inch of sediment at two of the sample locations north of the barrier footprint suggest that current and wave action has carried some oxidized iron-coated sand outside the original footprint of the barrier. The relatively elevated phosphorus levels in the shallow sediments collected from these two locations suggest that this oxidized iron-rich material is continuing to remove phosphorus from groundwater discharging to the pond or from the overlying pond water.

5.0 FUTURE MONITORING

During 2007 the USGS will collect groundwater samples for the analysis of TDP and flow measurements from the permanent monitoring network. USGS or AFCEE will also collect: (1) core samples from one background location and from three locations within the barrier for mineralogical analysis and chemical analysis of total iron, total manganese and total phosphorus; and (2) groundwater samples from six temporary drive point locations (two background and four barrier locations). Each temporary drive point location will be sampled at two mid-screen depths (e.g., 3.5 ft and 0.8 ft bpb) and each sample will be analyzed for dissolved iron, manganese, sulfate, nitrate, ammonium, chloride, calcium, magnesium, sodium, phosphorus, DO, alkalinity, methane, and field parameters. The data collected during 2007 will be used to conduct geochemical modeling of the background and barrier-treated groundwater in order to identify the phosphorus-removal mechanisms in the barrier and to evaluate the potential for long-term barrier effectiveness.

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APPENDIX A

U.S. Geological Survey 2006 Barrier Performance Report

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November 14, 2006

Jon Davis
AFCEE/MMR/IRP
318 East Inner Road
Otis ANG Base, MA 02542

Dear Jon,

During the period of August 3 - 21, 2006, the U.S. Geological Survey collected water samples from all permanent monitoring sites at the Ashumet Pond geochemical barrier and from 200 temporary pond-bottom drive points as part of continuing monitoring of the barrier's performance (fig. 1 and fig. 2). Enclosed are the field and laboratory results from samples collected from the pond-bottom piezometers, vertical and horizontal multiport samplers, vertical diffusion samplers, seepage meters, and temporary drive points. The purpose of this sampling round was to monitor the phosphorus plume prior to and as it passed through the zero-valent-iron barrier and to map the current concentrations of the phosphorus plume at three depths in the area of the barrier. These data will be compared to results from the pre-barrier (July 2004) and three post-barrier (October 2004, April 2005, and July 2005) sampling rounds (reported in letters dated 12/13/04, 7/21/05, and 9/26/05) to assess the long-term performance of the barrier.

Phosphorus concentrations in the water samples were measured in the field and laboratory. The field analyses were made on unfiltered samples with a colorimetric method that measures orthophosphate and are reported herein as phosphate concentrations. The laboratory analyses were made on filtered and acidified samples with an alkaline persulfate digestion method that measures total dissolved phosphorus and are reported herein as phosphorus concentrations. Because most phosphorus in the plume is present as orthophosphate, the two methods give similar results.

In general, the field and laboratory results indicate that phosphorus concentrations continue to be reduced as ground water flows through the geochemical barrier. Vertical samplers (multilevel and diffusion) measured phosphorus as great as 1.6 mg/L in the deepest ports below the barrier. At shallower depths within the barrier, phosphorus concentrations were reduced to undetectable values. The results from the horizontal multiport samplers (HMPS) show the continued presence of phosphate below the barrier,

with the highest concentrations near the shoreline. At the shallow HMPS within the barrier, phosphate was measured above 0.40 mg/L (as P) in only one sampling port. The results from the pond-bottom piezometers indicate little change in the distribution of phosphorus at depths greater than 10 feet below the pond bottom. However, the concentrations of the nitrogen species in the piezometers have decreased substantially in the past 13 months.

The stage of Ashumet Pond (46.15 ft on 8/9/06) was greater than 2 feet above mean stage for most of the summer months. With the higher-than-average stage, the phosphorus discharge area has temporarily shifted landward. This shift is most evident in the results from the temporary points driven into the pond bottom in and near the geochemical barrier.

I have included a brief description of each of the sampling methods and notable observations made during this sampling event:

Vertical Multilevel Samplers

Each of the 10 vertical multilevel samplers (MLS) consists of five sampling ports screened at 0, 0.8, 1.6, 2.2, and 3.4 feet below the pond bottom. The deepest interval (3.4 ft) is positioned to sample ground water below the geochemical barrier. MLS sites are located within the barrier and outside (pondward or to the south) of the barrier (fig. 2). The field and laboratory results from the pre- (July 2004), post1- (October 2004), post2- (April 2005), and post3- (July 2005) sampling rounds are shown in table 1. Figures 3a-j show temporal changes in profiles of specific conductance, dissolved oxygen, and phosphorus for the four or five (partial round in April 2005) sampling dates.

Vertical Diffusion Samplers

A diffusion chamber is a vertical stack of 13 bottles filled with deionized water and having open tops that are covered with a 10-μm mesh. This stack of bottles is inserted into a PVC casing that was permanently installed in the pond bottom during the barrier installation. After about 2 weeks of equilibration time in the pond bottom, the bottles are harvested, and specific conductance and field phosphate are measured. The results from all sampling rounds are shown in table 2. Figures 4a-c show the vertical distributions of specific conductance and phosphate for each of the eight diffusion sampling sites. Figures 4a-c also show the thickness of the iron zone (for August 2006) as indicated visually by reddish brown or gray film on the sample bottles.

Horizontal Multiport Samplers

Horizontal multiport samplers (HMPS) consist of 15 sampling tubes that extend pondward from shore to various distances from shore. These samplers were buried in the pond bottom at two depths (0.5 and 3.0 feet below the pond bottom) during installation of the geochemical barrier. Two coupled horizontal multiport samplers (a total of four) were used at Ashumet Pond (lines 1 and 2, fig. 2). Results from all sampling rounds are shown in table 3. Figures 5a and 5b show horizontal transects of specific conductance, pH, dissolved oxygen, and phosphate for August 2006. Figures 6a and 6b show the horizontal profiles for specific conductance and phosphate for the October 2004, July 2005, and

August 2006 sampling rounds. In general, elevated phosphate is present in the deep HMPS at each location (lines 1 and 2) and is absent or very low at the shallow sampler after the ground water has passed through the barrier. The HMPS also show a shift in location (towards shore) of the discharge footprint owing to the rise in pond stage.

Pond-Bottom Piezometers

Twelve pond-bottom piezometers extending as deep as 100 feet were sampled as part of the August 2006 sampling round. Piezometer clusters at the shoreline (F633), 55 feet from mean shoreline (F635), and 110 feet from mean shoreline (F636) were sampled at depths of 10, 30, 60, and 100 feet below the pond bottom. Results from the sampling (and previous sampling rounds) are shown in table 4 and figures 7a-c. In figures 7a-c, the phosphorus and nitrogen results from the piezometer sampling were combined with data (July 2006) from upgradient wells to produce the vertical sections.

Seepage Meters

Eight permanent seepage meters were measured on August 8, 2006 (fig. 2). Meters 1a and b are located outside and to the south of the barrier. Paired meters 2a and 2b, 3a and 3b, and 4a and 4b are located in the barrier at varying distances from shore. Each meter was capped on July 31 and allowed to equilibrate for 8 days. The flow rate through each meter was measured for four measurement trials (table 5). Field orthophosphate was measured in the discharging ground water on at least one trial from each meter. The flow rates and subsequent phosphorus flux rates are graphed in figure 8. In general, the highest flow rates were measured in meters closest to the shoreline. Minimal phosphorus flux (a maximum rate of 7.3 mg/d) was measured in the meters located in the barrier area. The control site meters yielded phosphorus fluxes ranging from 154 to 318 mg/d.

Temporary Pond-Bottom Drive Points

During August 3-21, 2006, 200 temporary drive points were installed at 76 locations to delineate the current distribution of phosphorus and nitrogen in ground water at 0.5, 1.5, and 3.0 feet below the pond bottom in the area of the geochemical barrier (fig. 9a). The field and laboratory results are tabulated in table 6 and table 7. Figures 9b–i show the distributions of specific conductance, dissolved oxygen, pH, temperature, field phosphate, phosphorus, nitrate, and ammonium at the three depth intervals. The maps were generated from digitized contours using GIS to interpolate concentration values and then colorize by value. Figure 9g shows a decrease in phosphorus at progressively shallower depths in the barrier below the pond bottom. Average phosphorus concentrations over the area of the geochemical barrier, as determined using GIS, are 0.24, 0.28, and 1.01 mg/L for the 0.5-, 1.5- and 3.0-ft sampling depths, respectively.

Please contact me by phone (508-490-5016) or via email at tmccobb@usgs.gov if you have any questions about the monitoring network or the results from the August 2006 sampling round. A compact disc (CD) with the electronic versions of all tables and figures has been enclosed with this letter.

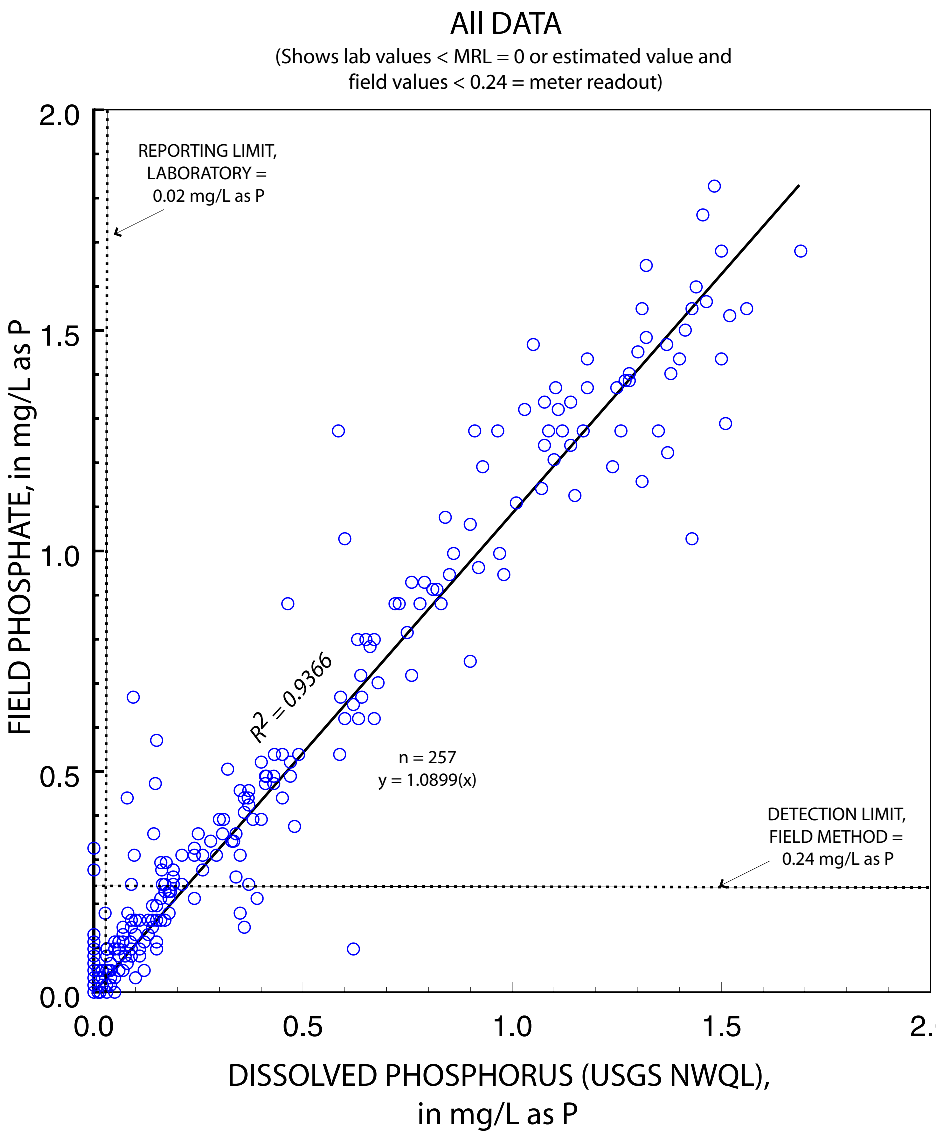
Sincerely yours,

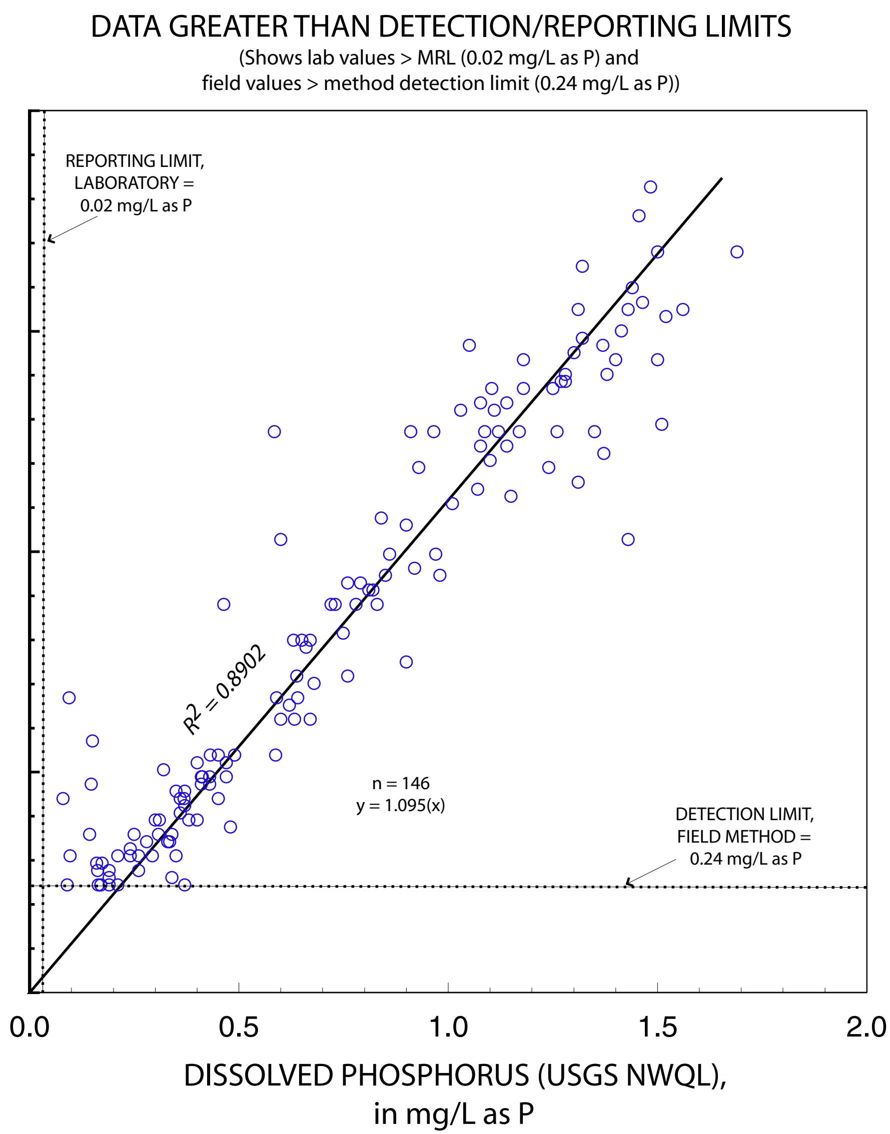
Timothy D. McCobb
Hydrologist

cc: Jonathan Blount, CH2MHILL

APPENDIX B

Comparison of Field- and Laboratory-Determined Phosphorus Concentrations





Comparison of field- and laboratory-determined phosphorus concentrations in pond-bottom ground water sampled in August 2006, Ashumet Pond, MA

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APPENDIX C

Statistical Comparison of Phosphorus Concentrations vs. Depth in Barrier and Background Locations

Appendix C
Statistical Comparison of Phosphorus Concentrations vs. Depth in Barrier and Background Locations
Final Ashumet Pond 2006 Phosphorus Barrier Technical Memorandum

Inside Barrier 0.5 ft bpb Phosphorus, Dissolved (mg/L)	Inside Barrier 0.5 ft bpb Phosphorus, Dissolved (mg/L)	Inside Barrier 3.0 ft bpb Phosphorus, Dissolved (mg/L)	Inside Barrier 3.0 ft bpb Phosphorus, Dissolved (mg/L)
Mean	**0.12**	**Mean**	**0.89**
Standard Error	0.02	Standard Error	0.08
Median	0.09	Median	0.73
Mode	0.02	Mode	1.50
Standard Deviation	0.10	Standard Deviation	0.50
Sample Variance	0.01	Sample Variance	0.25
Kurtosis	1.96	Kurtosis	-1.60
Skewness	1.56	Skewness	0.10
Range	**0.39**	**Range**	**1.58**
Minimum	0.01	Minimum	0.11
Maximum	0.40	Maximum	1.69
Sum	4.26	Sum	33.01
Count	37.00	Count	37.00

Outside Barrier 0.5 ft bpb Phosphorus, Dissolved (mg/L)	Outside Barrier 0.5 ft bpb Phosphorus, Dissolved (mg/L)	Outside Barrier 3.0 ft bpb Phosphorus, Dissolved (mg/L)	Outside Barrier 3.0 ft bpb Phosphorus, Dissolved (mg/L)
Mean	**0.60**	**Mean**	**0.64**
Standard Error	0.08	Standard Error	0.07
Median	0.45	Median	0.53
Mode	0.19	Mode	0.36
Standard Deviation	0.42	Standard Deviation	0.38
Sample Variance	0.17	Sample Variance	0.15
Kurtosis	-1.19	Kurtosis	-1.31
Skewness	0.44	Skewness	0.41
Range	**1.30**	**Range**	**1.16**
Minimum	0.02	Minimum	0.14
Maximum	1.32	Maximum	1.30
Sum	18.08	Sum	19.11
Count	30.00	Count	30.00

Notes:

Censored data used in the statistical analysis excludes all locations with ND data or with phosphorus concentrations equal to or less than 0.1 mg/L at a depth of 3.0 feet. ND or "less than" data at 0.5 feet in remaining locations was converted to the numeric value of the detection limit.

ft bpb = feet below the pond bottom

mg/L = milligrams per liter

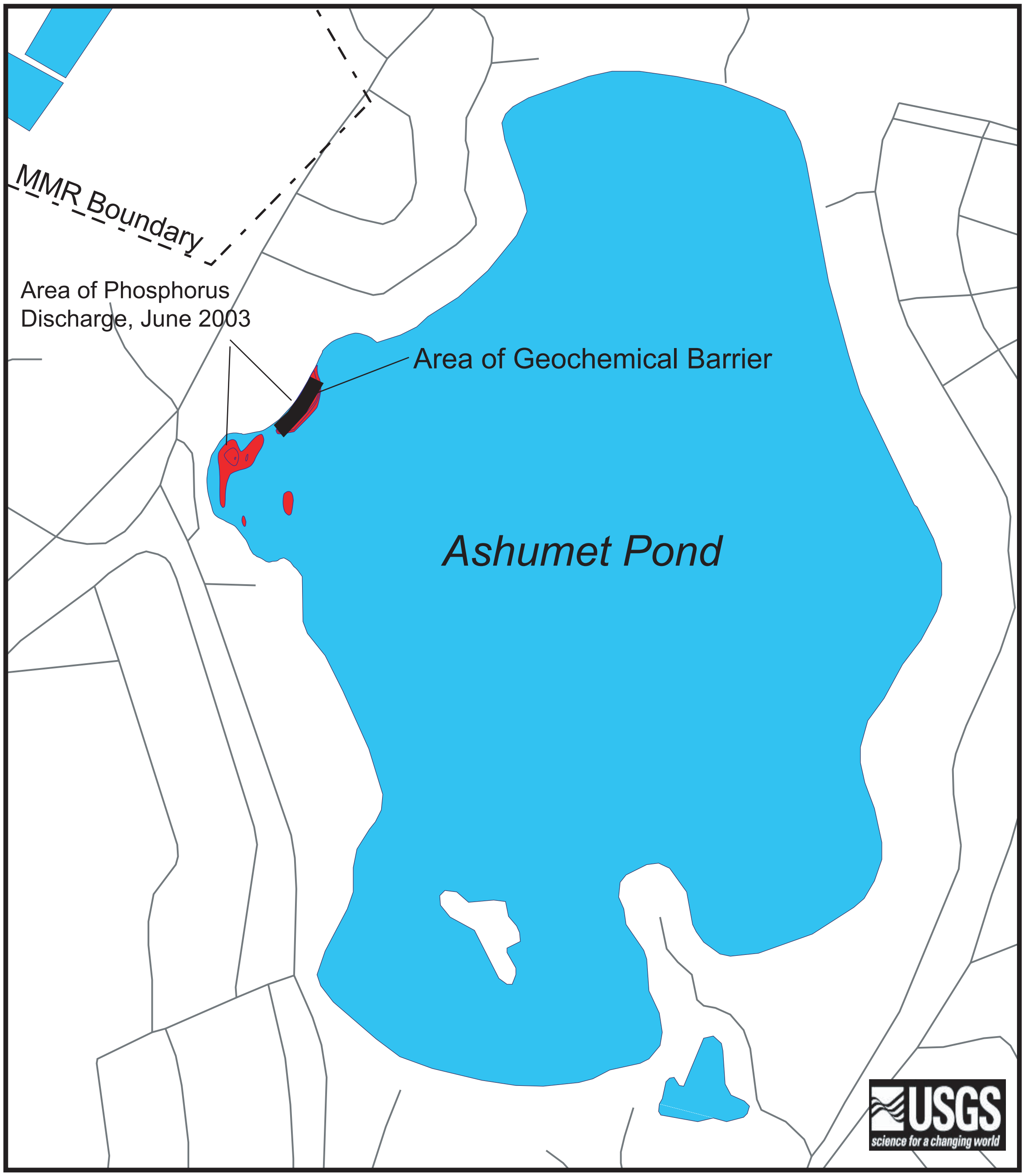

Figure 1. Area of the geochemical barrier and extent of the discharge area of the phosphorus plume at Ashumet Pond in June 2003.

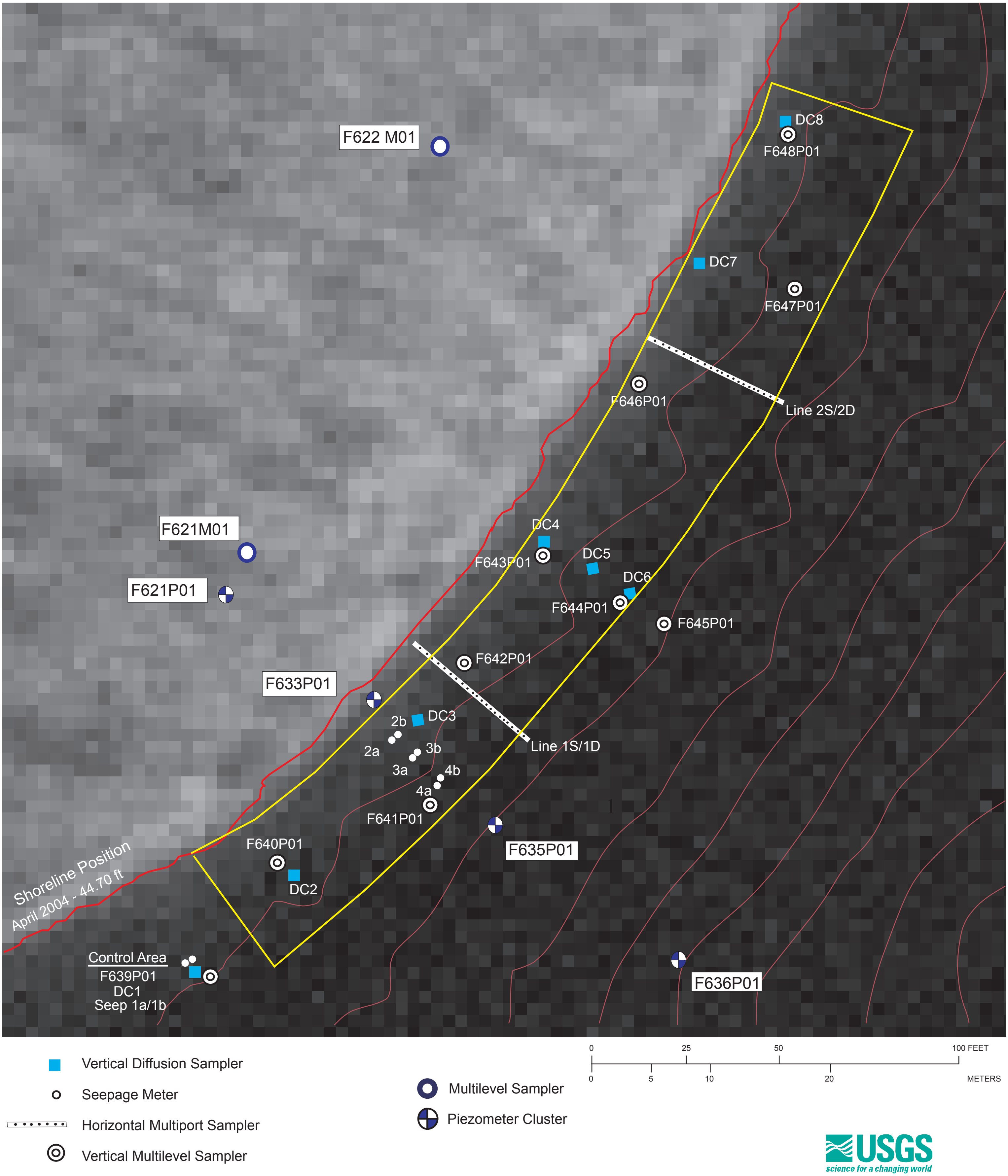

Figure 2. Locations of permanent seepage meters, vertical multilevel samplers, horizontal multiport samplers, and vertical diffusion samplers in the geochemical barrier at Ashumet Pond.

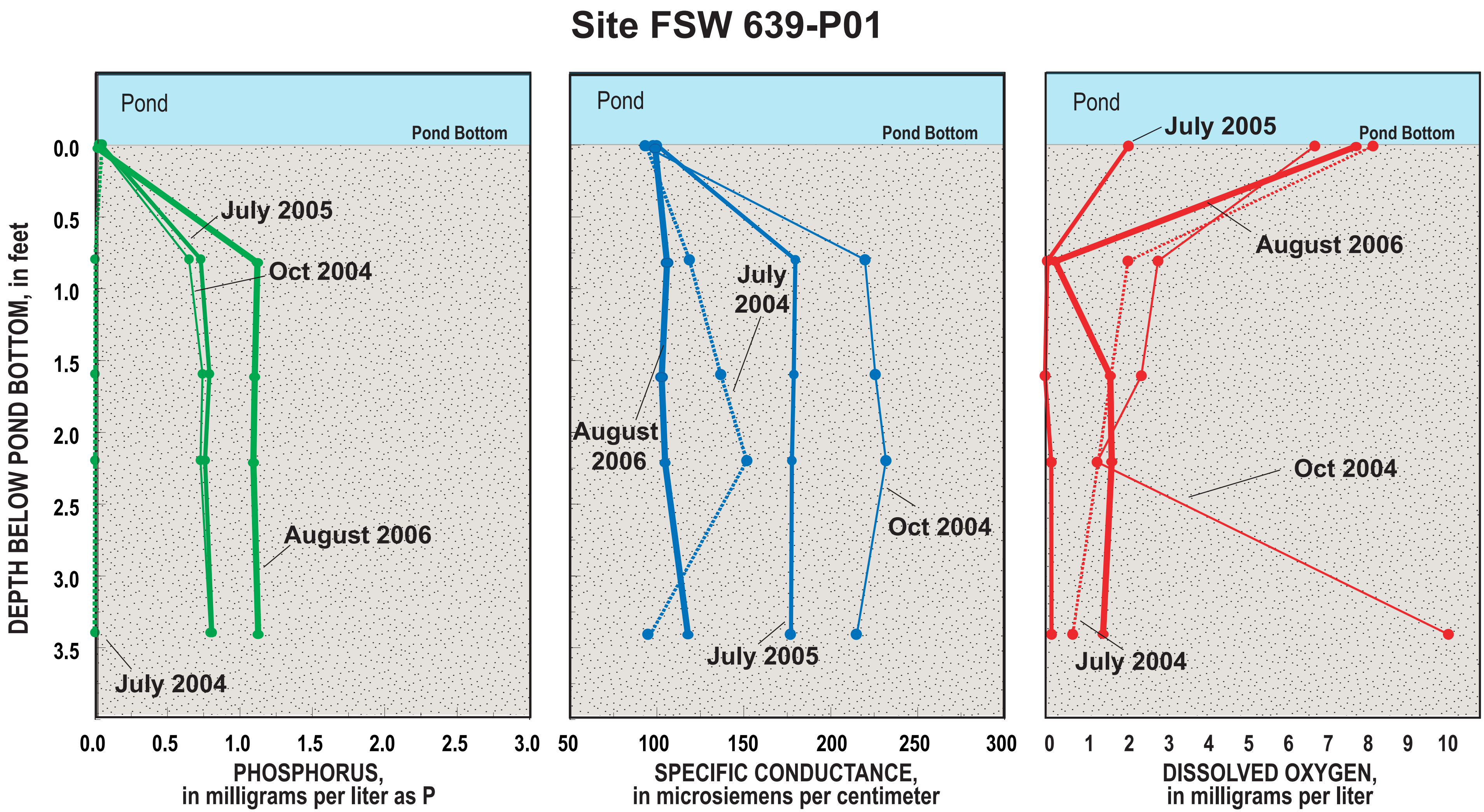

Figure 3a. Geochemical profiles from pond-bottom vertical multilevel samplers, including dissolved phosphorus, specific conductance, and dissolved oxygen, prior to installation of the geochemical barrier (July 2004), and at 2 (October 2004), 11 (July 2005), and 23 months (August 2006) after installation of the geochemical barrier.

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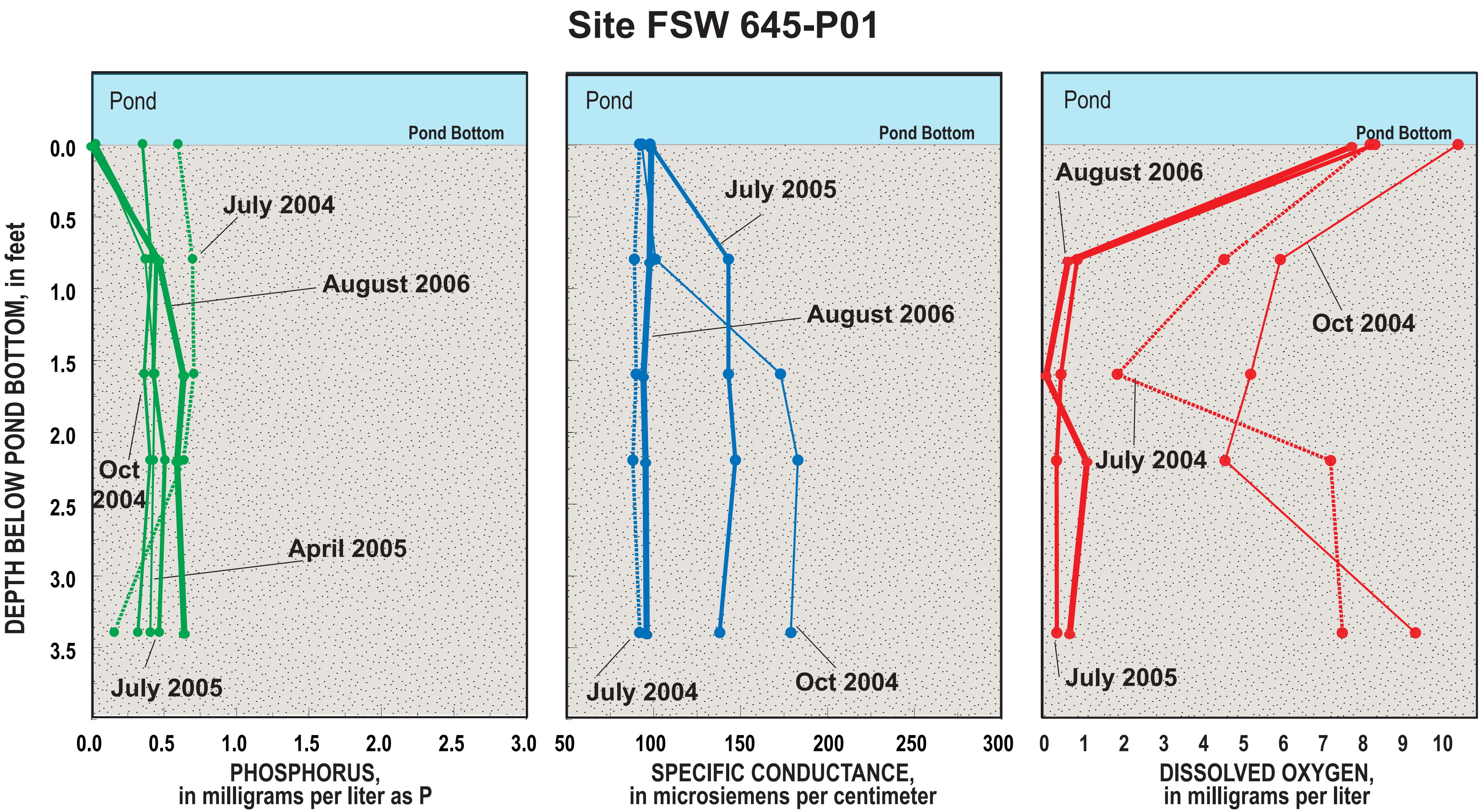

Figure 3g. Geochemical profiles from pond-bottom vertical multilevel samplers, including dissolved phosphorus, specific conductance, and dissolved oxygen, prior to installation of the geochemical barrier (July 2004), and at 2 (October 2004), 11 (July 2005), and 23 months (August 2006) after installation of the geochemical barrier.

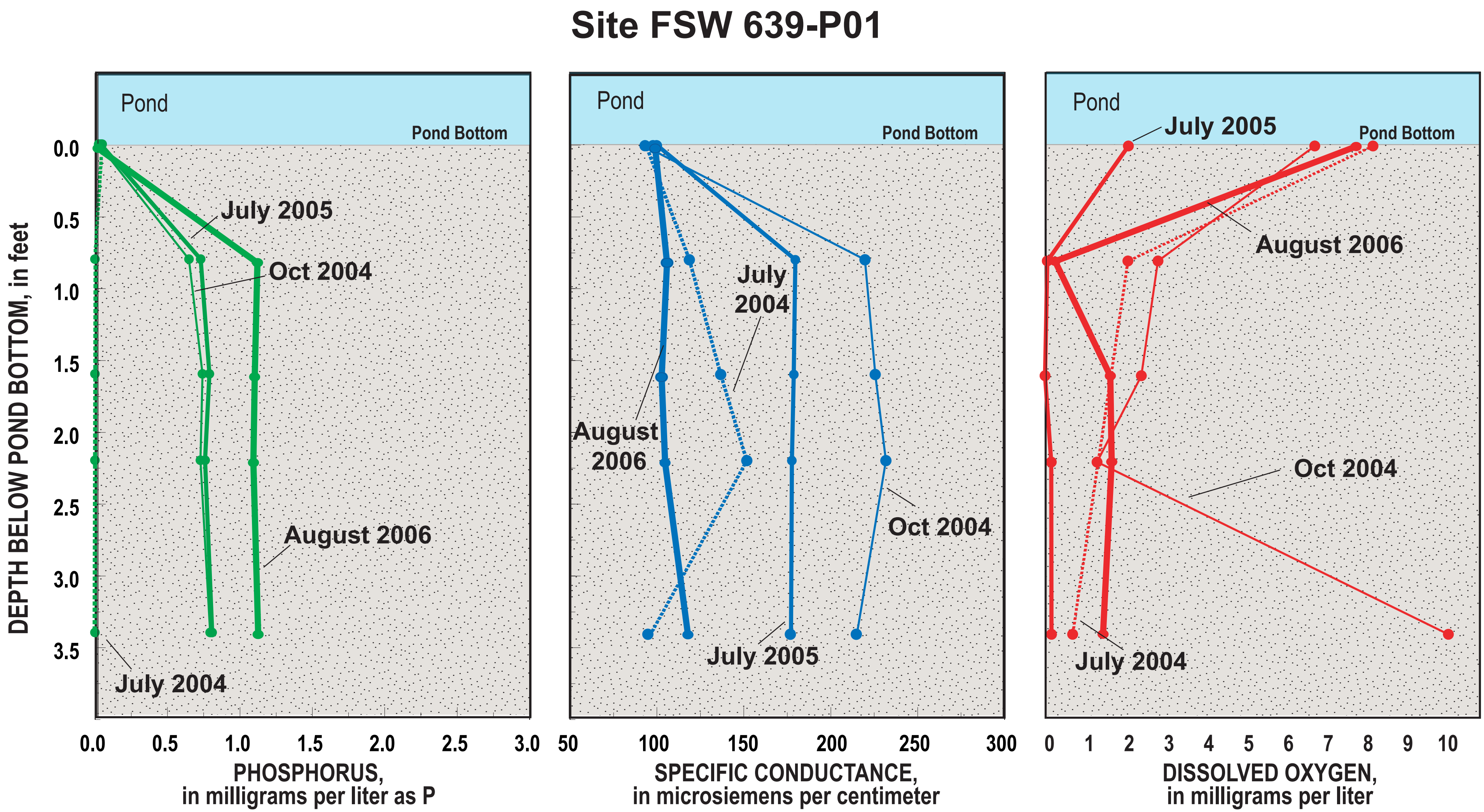

Figure 3a. Geochemical profiles from pond-bottom vertical multilevel samplers, including dissolved phosphorus, specific conductance, and dissolved oxygen, prior to installation of the geochemical barrier (July 2004), and at 2 (October 2004), 11 (July 2005), and 23 months (August 2006) after installation of the geochemical barrier.

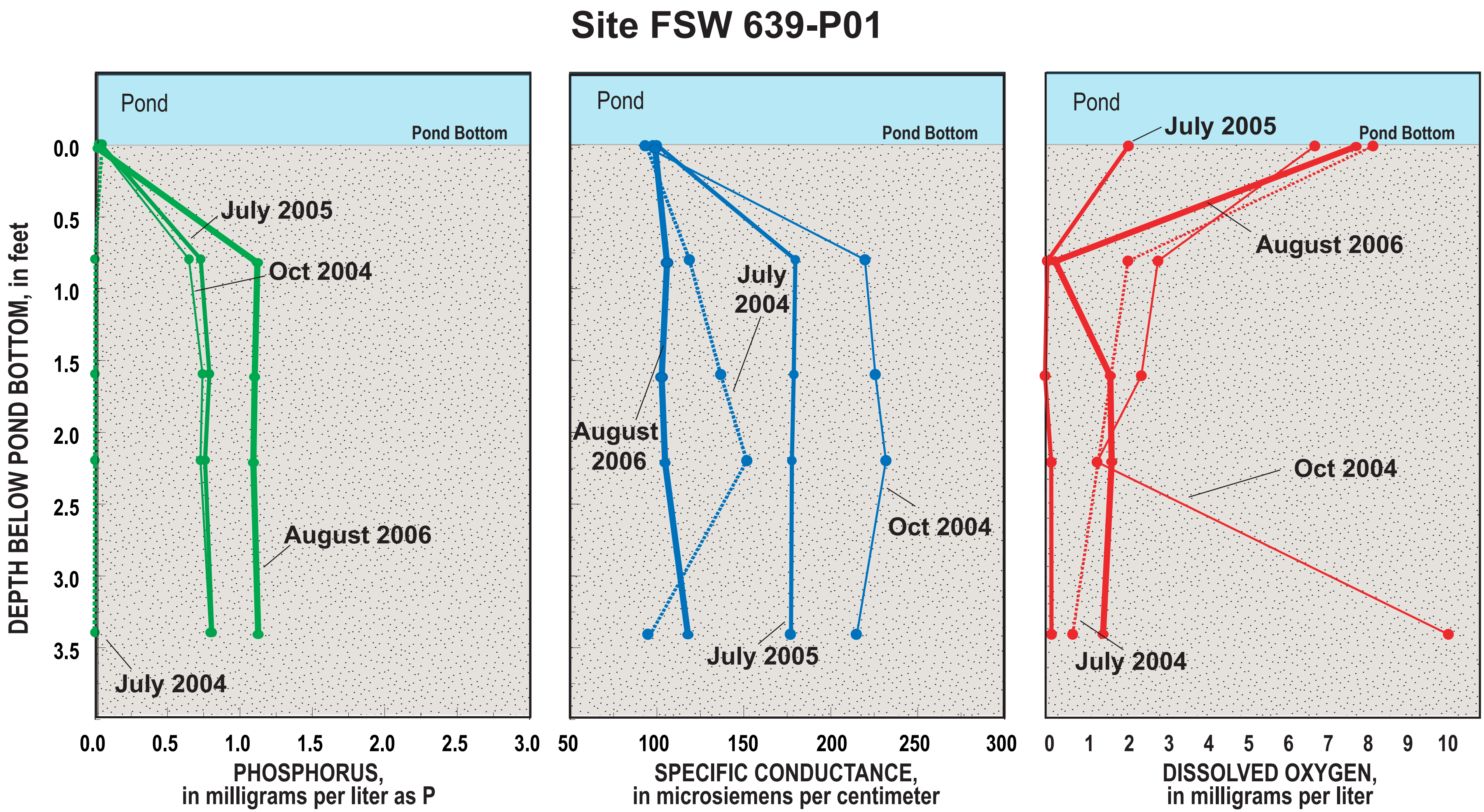

Figure 3a. Geochemical profiles from pond-bottom vertical multilevel samplers, including dissolved phosphorus, specific conductance, and dissolved oxygen, prior to installation of the geochemical barrier (July 2004), and at 2 (October 2004), 11 (July 2005), and 23 months (August 2006) after installation of the geochemical barrier.

Site FSW 640-P01

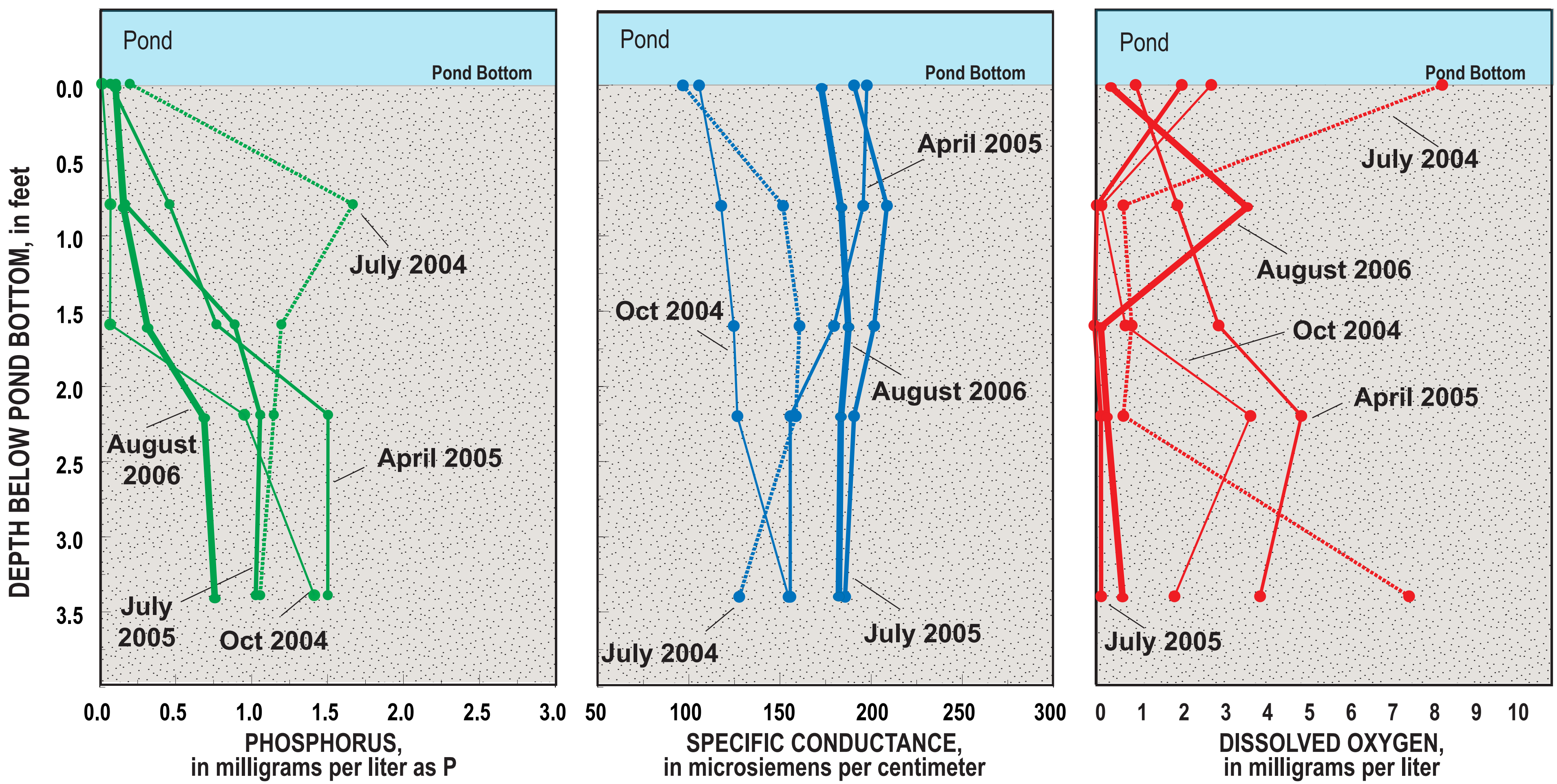

Figure 3b. Geochemical profiles from pond-bottom vertical multilevel samplers, including dissolved phosphorus, specific conductance, and dissolved oxygen, prior to installation of the geochemical barrier (July 2004), and at 2 (October 2004), 11 (July 2005), and 23 months (August 2006) after installation of the geochemical barrier.

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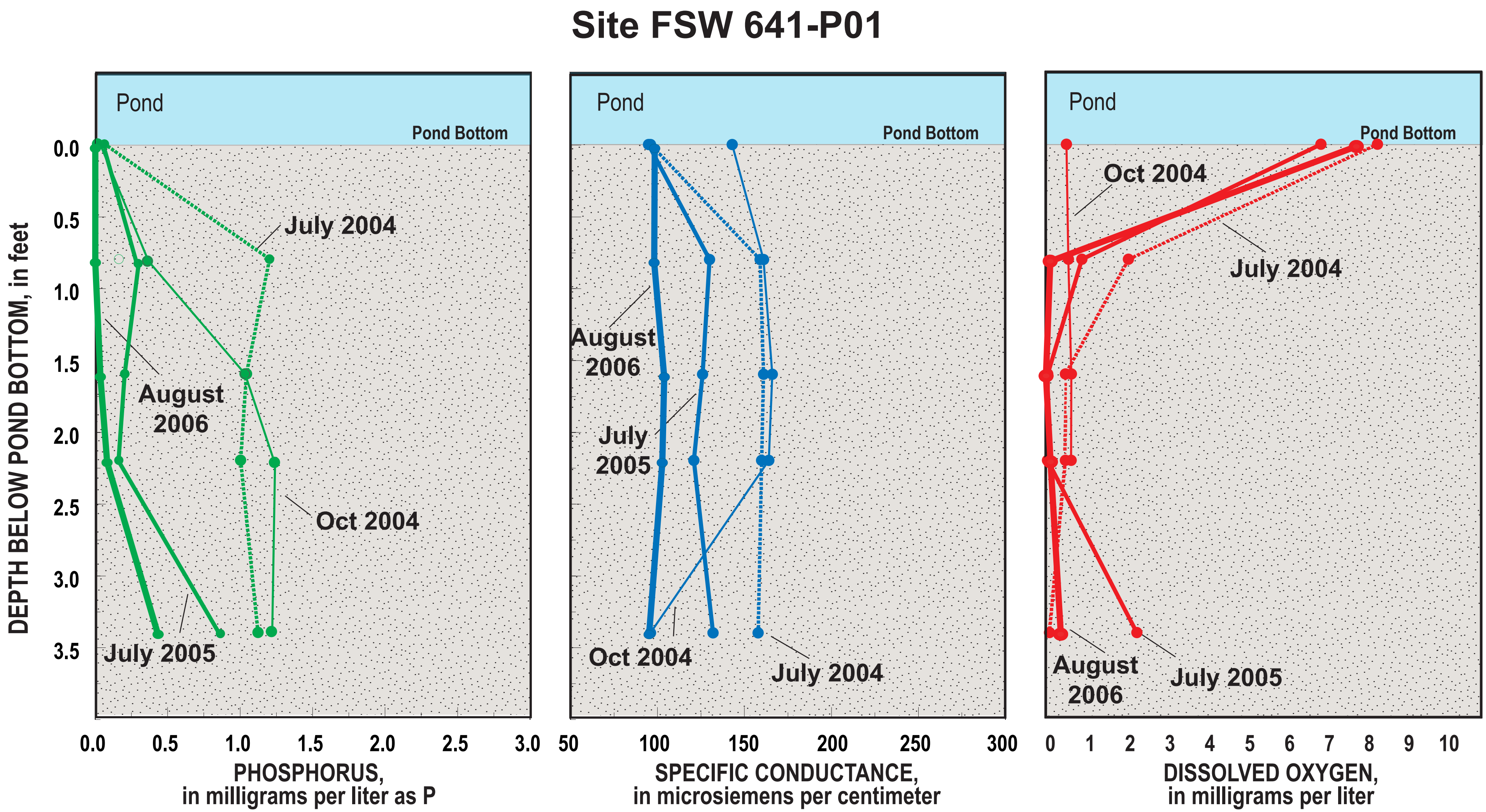

Figure 3c. Geochemical profiles from pond-bottom vertical multilevel samplers, including dissolved phosphorus, specific conductance, and dissolved oxygen, prior to installation of the geochemical barrier (July 2004), and at 2 (October 2004), 11 (July 2005), and 23 months (August 2006) after installation of the geochemical barrier.

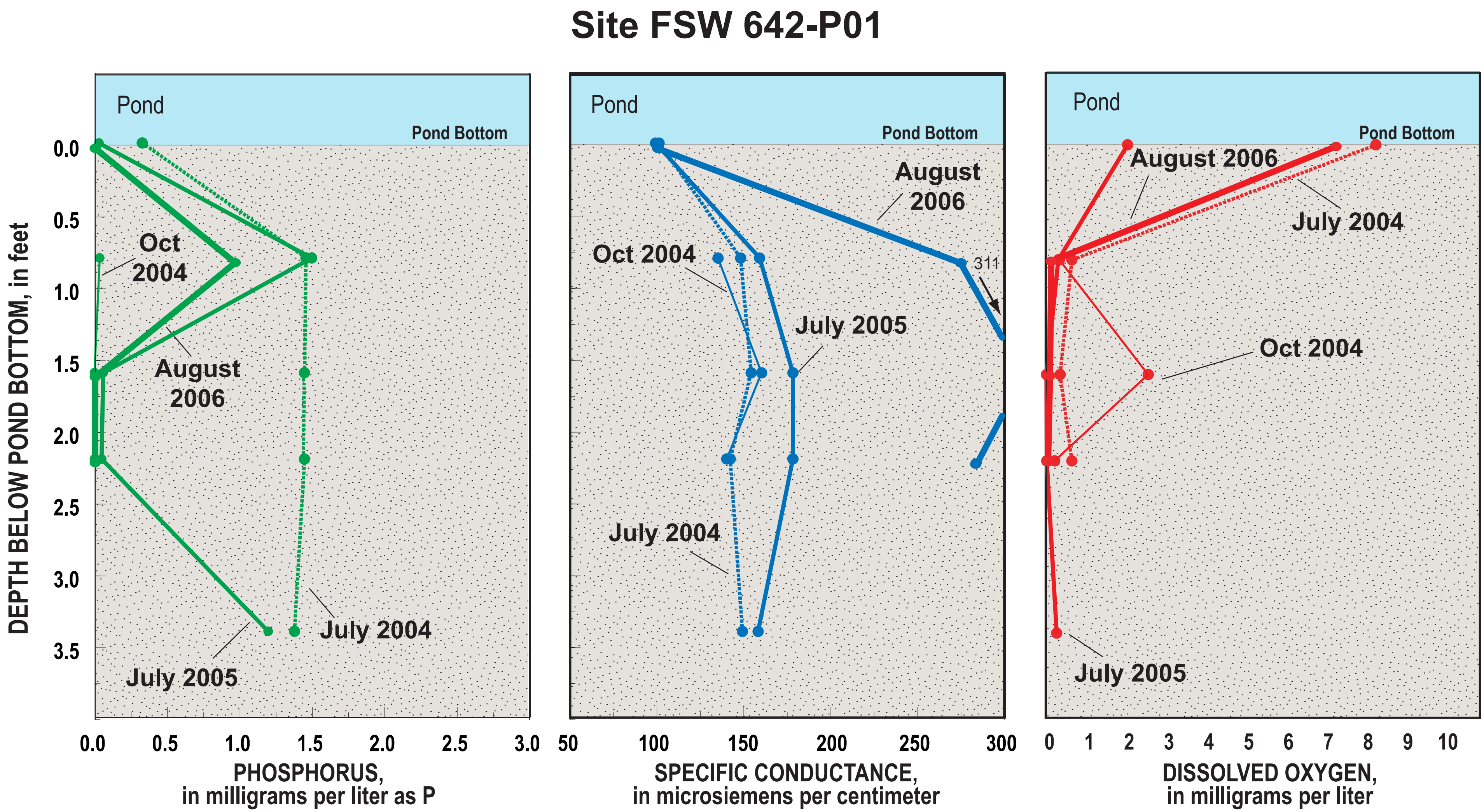

Figure 3d. Geochemical profiles from pond-bottom vertical multilevel samplers, including dissolved phosphorus, specific conductance, and dissolved oxygen, prior to installation of the geochemical barrier (July 2004), and at 2 (October 2004), 11 (July 2005), and 23 months (August 2006) after installation of the geochemical barrier.

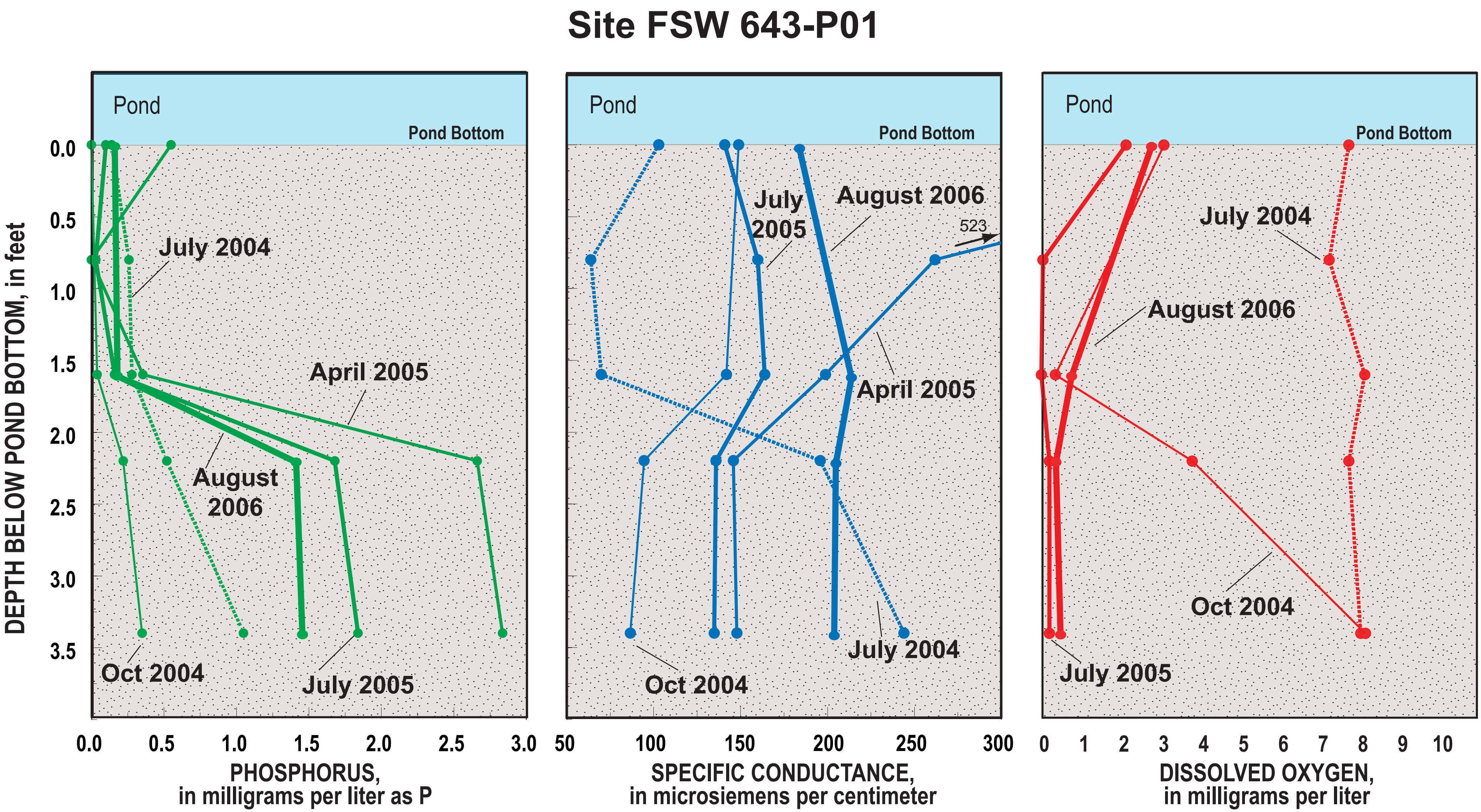

Figure 3e. Geochemical profiles from pond-bottom vertical multilevel samplers, including dissolved phosphorus, specific conductance, and dissolved oxygen, prior to installation of the geochemical barrier (July 2004), and at 2 (October 2004), 11 (July 2005), and 23 months (August 2006) after installation of the geochemical barrier.

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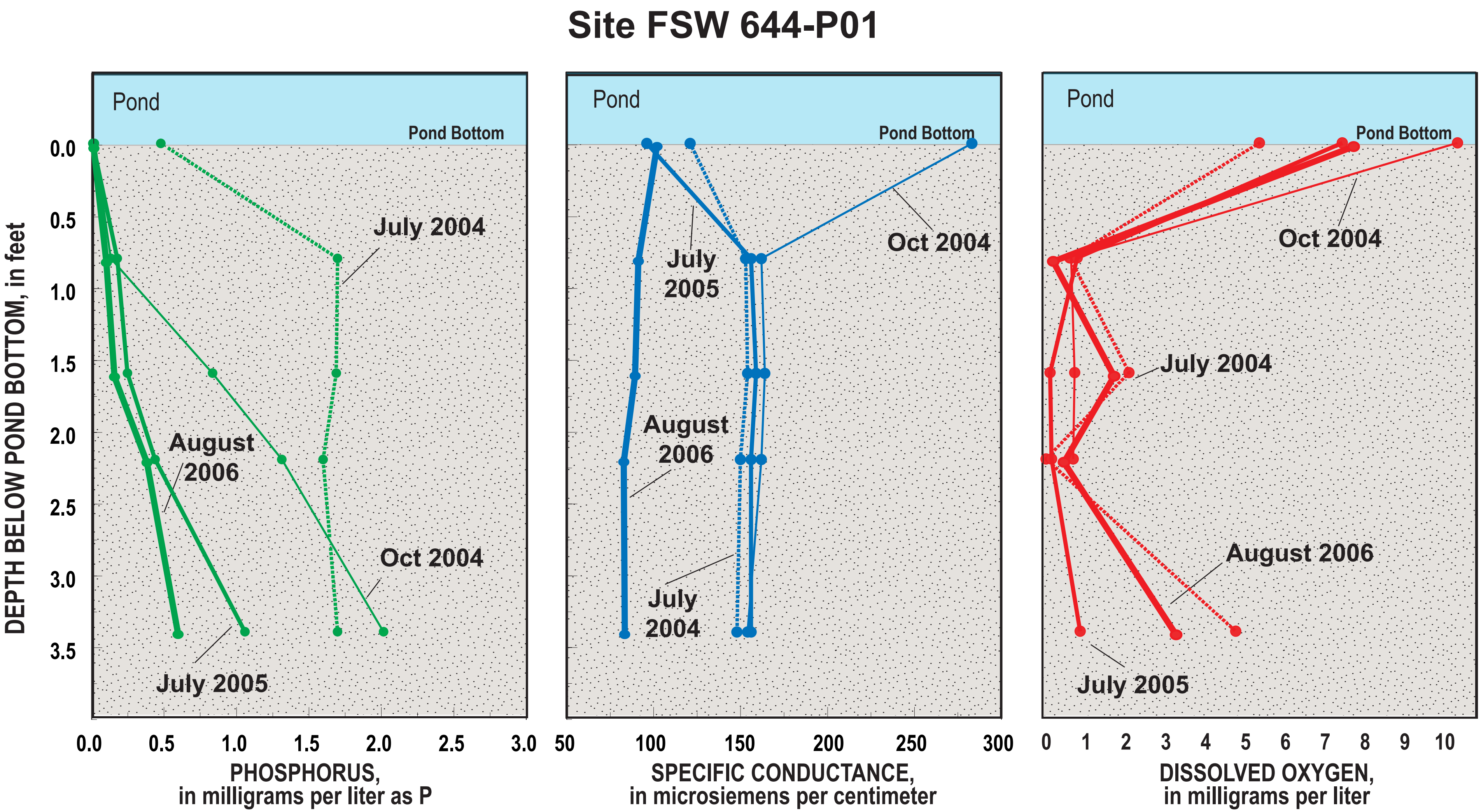

Figure 3f. Geochemical profiles from pond-bottom vertical multilevel samplers, including dissolved phosphorus, specific conductance, and dissolved oxygen, prior to installation of the geochemical barrier (July 2004), and at 2 (October 2004), 11 (July 2005), and 23 months (August 2006) after installation of the geochemical barrier.

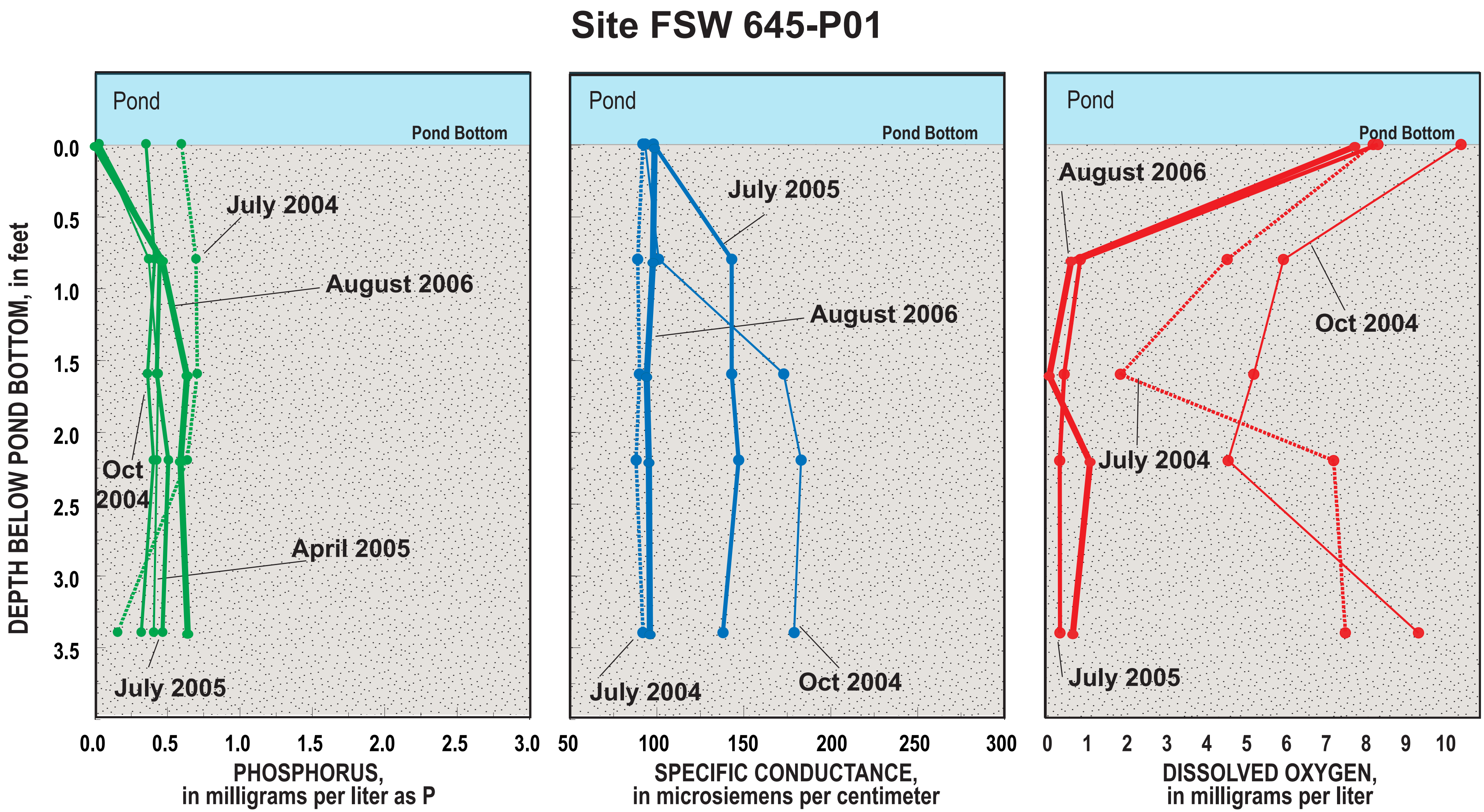

Figure 3g. Geochemical profiles from pond-bottom vertical multilevel samplers, including dissolved phosphorus, specific conductance, and dissolved oxygen, prior to installation of the geochemical barrier (July 2004), and at 2 (October 2004), 11 (July 2005), and 23 months (August 2006) after installation of the geochemical barrier.

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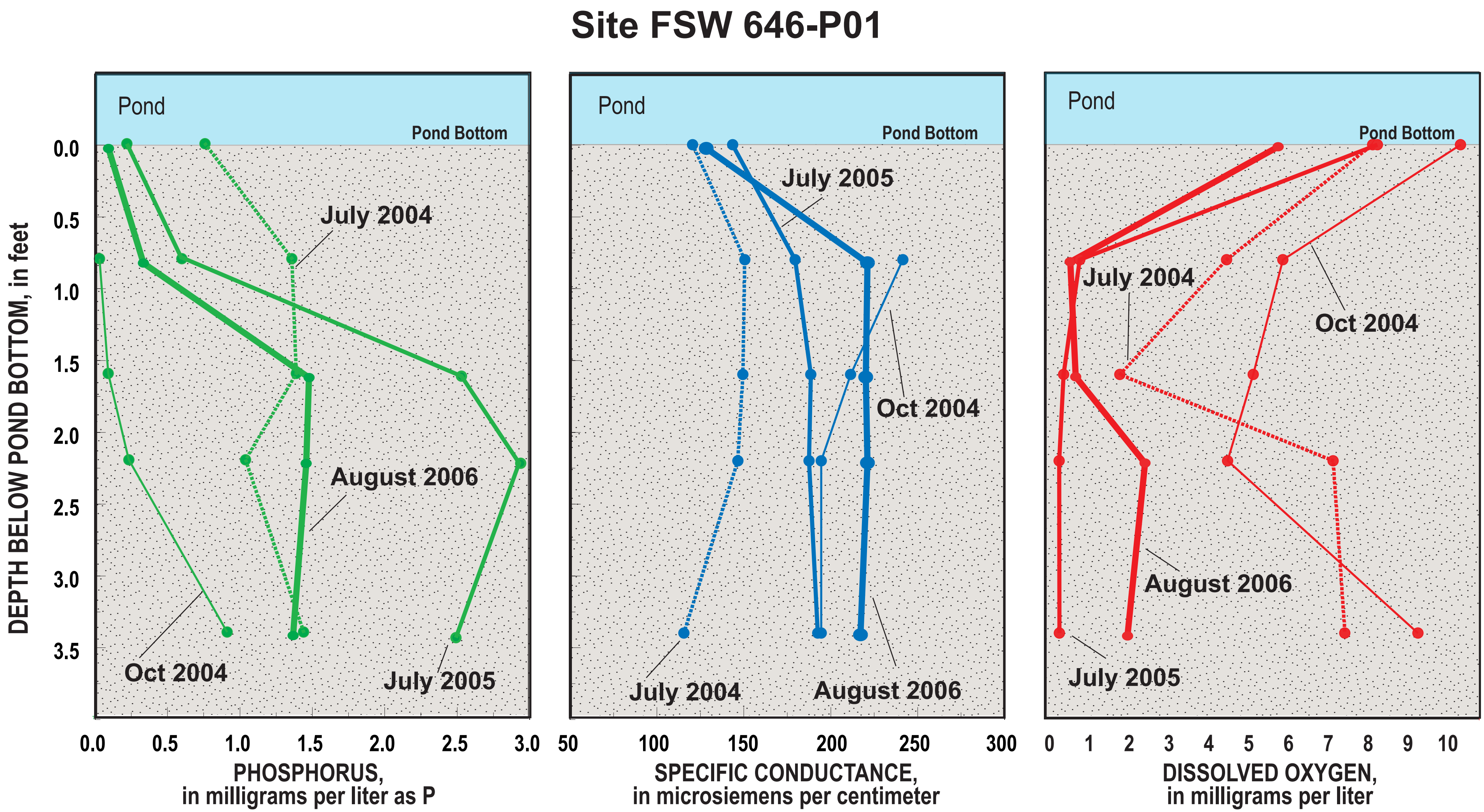

Figure 3h. Geochemical profiles from pond-bottom vertical multilevel samplers, including dissolved phosphorus, specific conductance, and dissolved oxygen, prior to installation of the geochemical barrier (July 2004), and at 2 (October 2004), 11 (July 2005), and 23 months (August 2006) after installation of the geochemical barrier.

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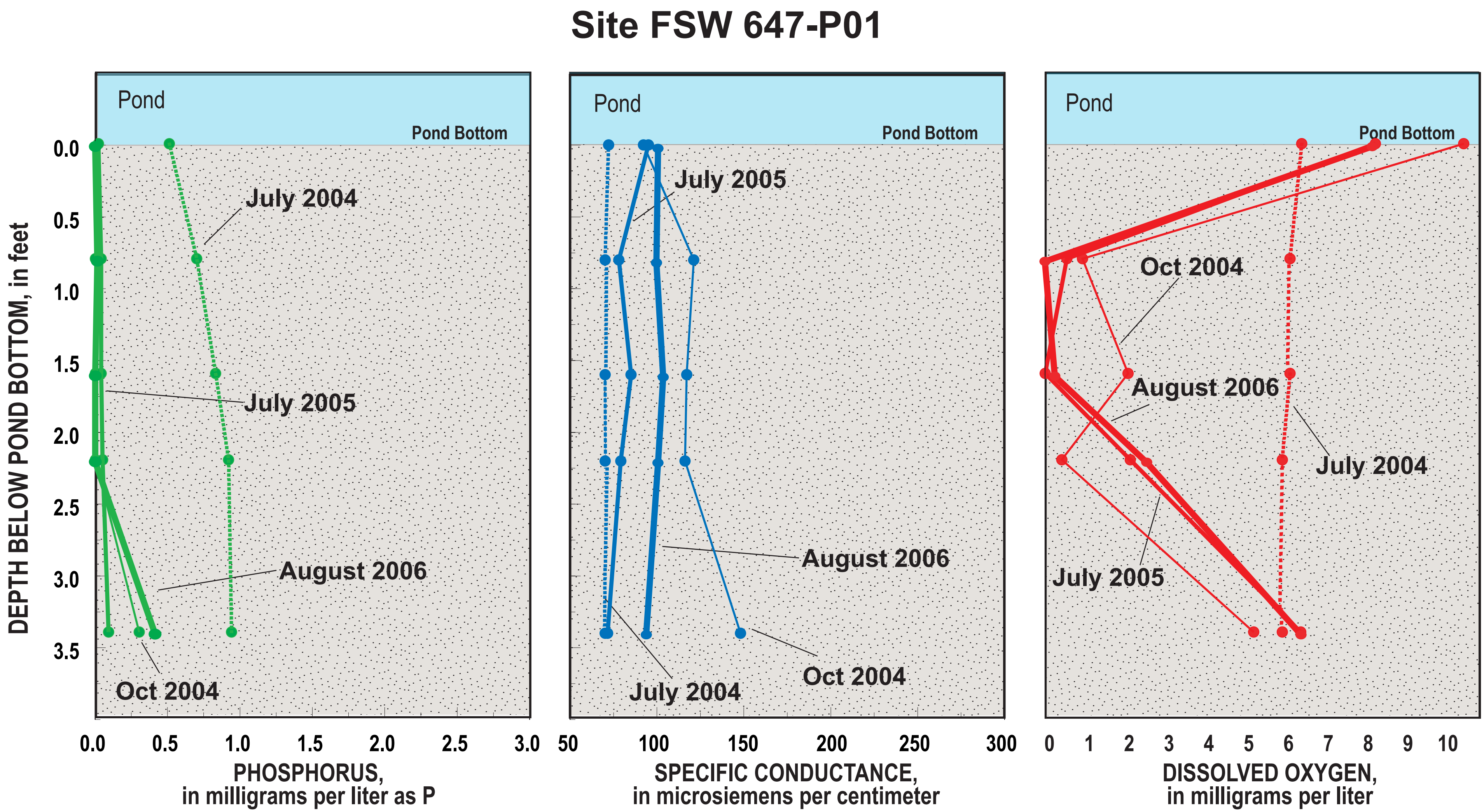

Figure 3i. Geochemical profiles from pond-bottom vertical multilevel samplers, including dissolved phosphorus, specific conductance, and dissolved oxygen, prior to installation of the geochemical barrier (July 2004), and at 2 (October 2004), 11 (July 2005), and 23 months (August 2006) after installation of the geochemical barrier.

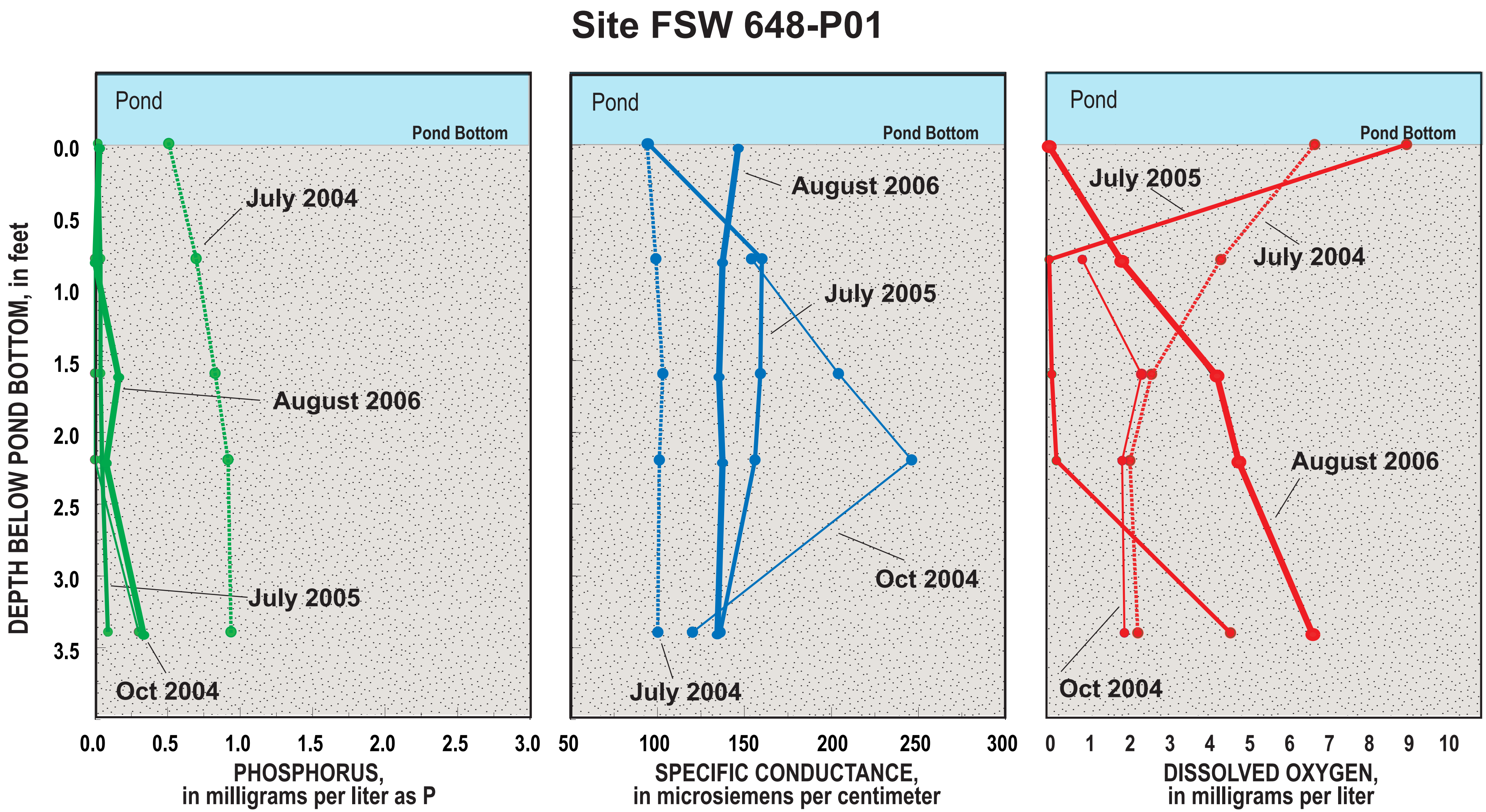

Figure 3j. Geochemical profiles from pond-bottom vertical multilevel samplers, including dissolved phosphorus, specific conductance, and dissolved oxygen, prior to installation of the geochemical barrier (July 2004), and at 2 (October 2004), 11 (July 2005), and 23 months (August 2006) after installation of the geochemical barrier.

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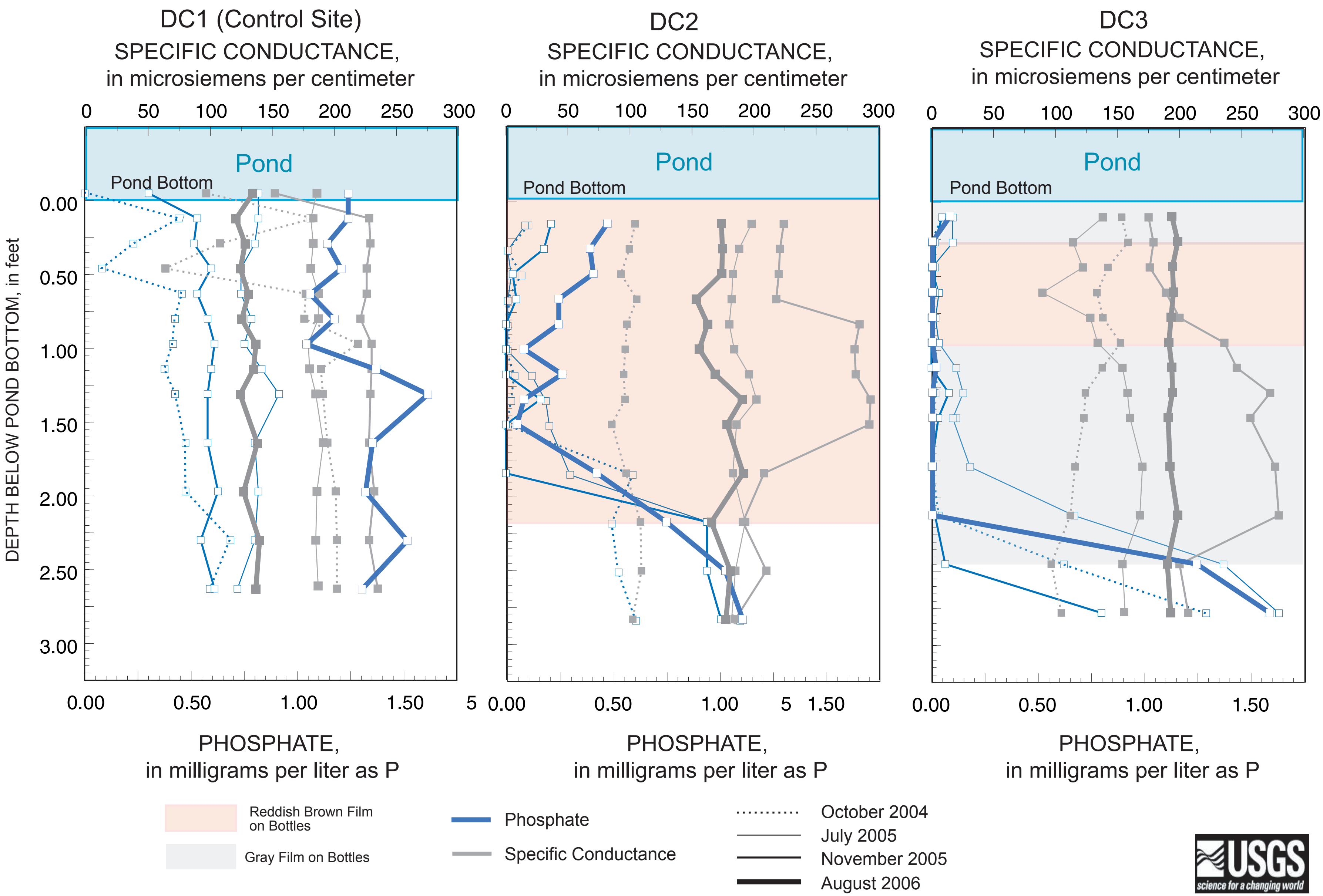


Figure 4a. Geochemical profiles from pond-bottom vertical diffusion chambers at 2 months (October 2004), 11 months (July 2005), 15 months (November 2005), and 23 months (August 2006) after installation of the geochemical barrier.

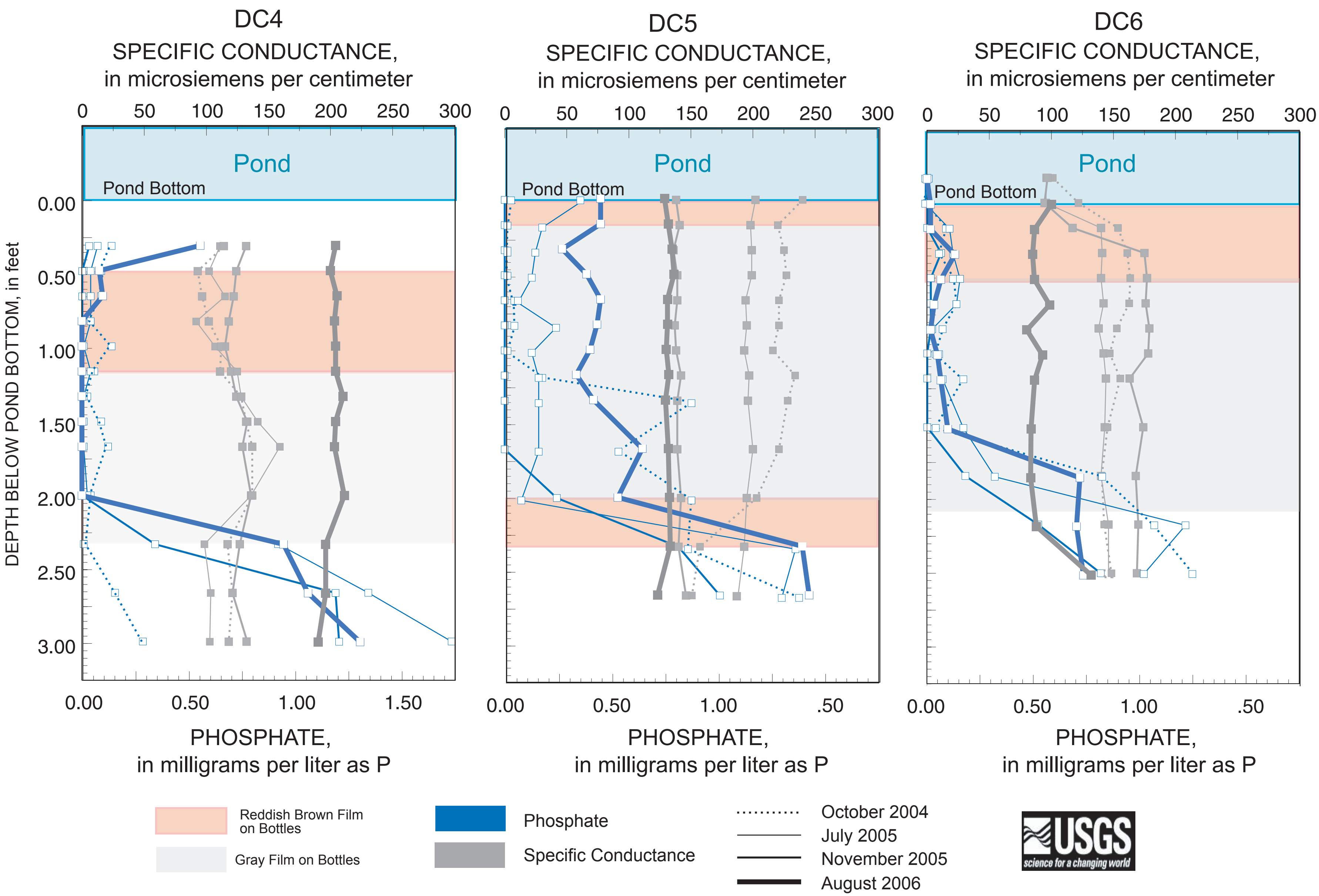


Figure 4b. Geochemical profiles from pond-bottom vertical diffusion chambers at 2 months (October 2004), 11 months (July 2005), 15 months (November 2005), and 23 months (August 2006) after installation of the geochemical barrier.

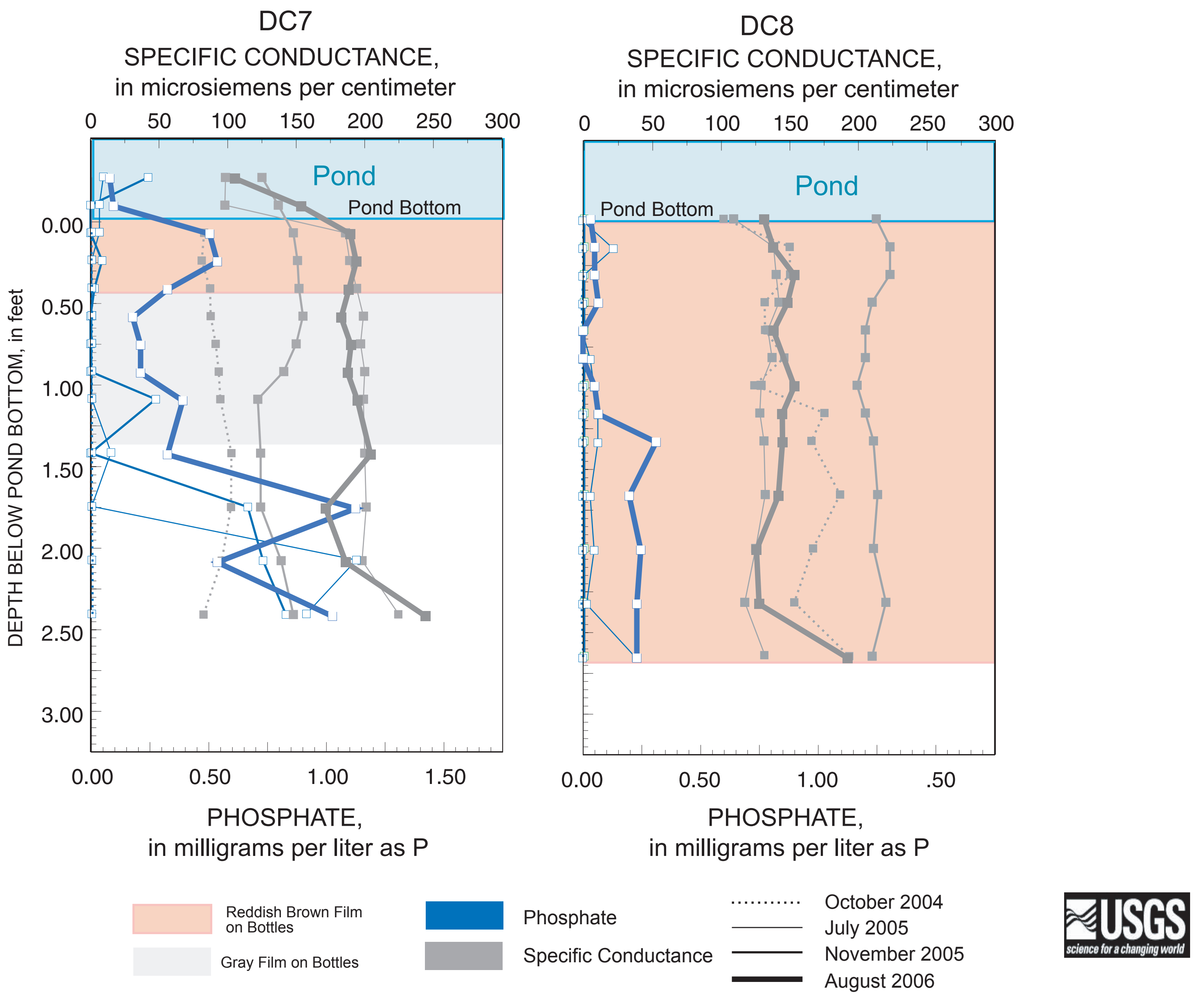


Figure 4c. Geochemical profiles from pond-bottom vertical diffusion chambers at 2 months (October 2004), 11 months (July 2005), 15 months (November 2005), and 23 months (August 2006) after installation of the geochemical barrier.

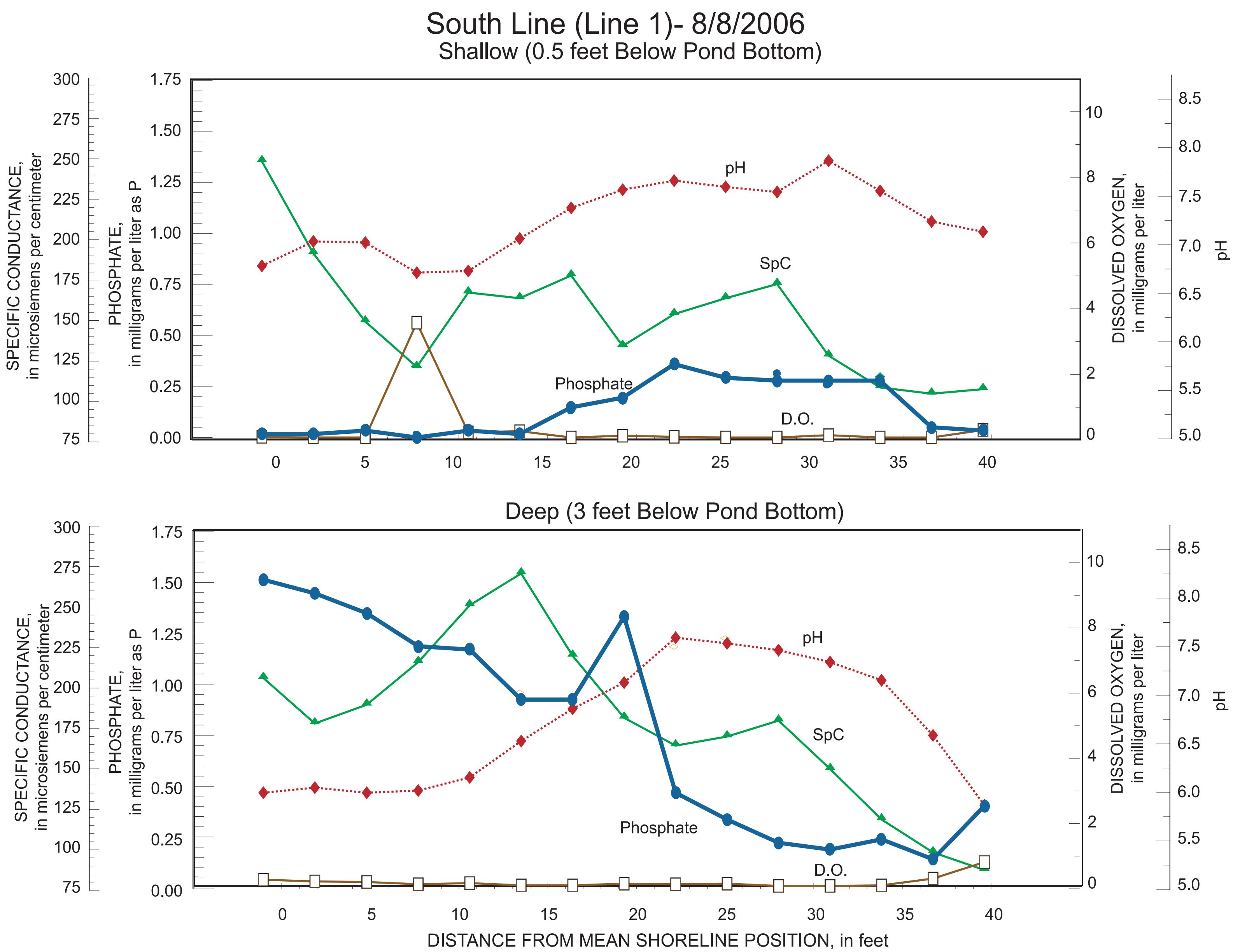


Figure 5a. Geochemical transects from horizontal multiport samplers along line 1 (south) sampled 23 months (August 2006) after barrier installation.

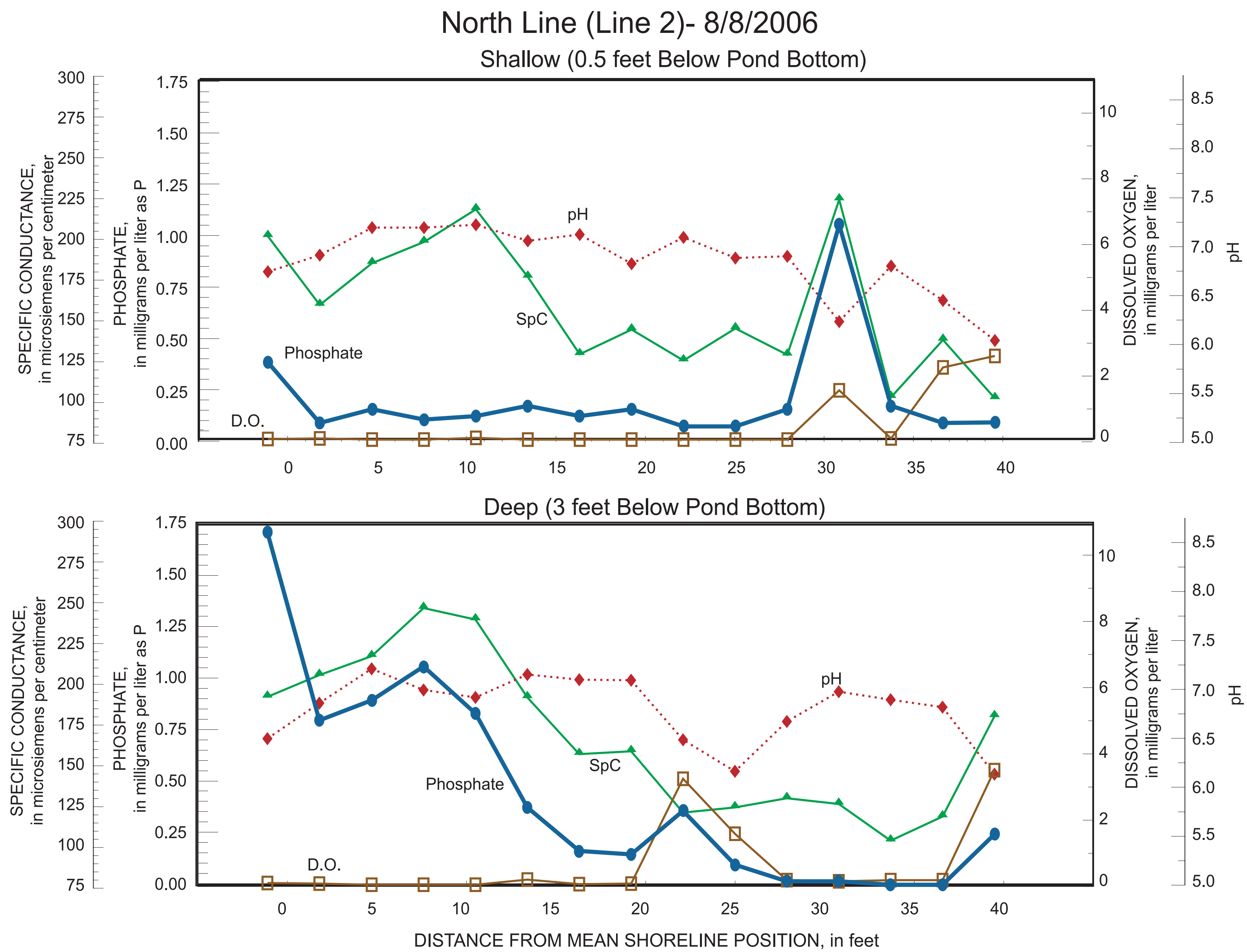


Figure 5b. Geochemical transects from horizontal multiport samplers along line 2 (north) sampled 23 months (August 2006) after barrier installation.

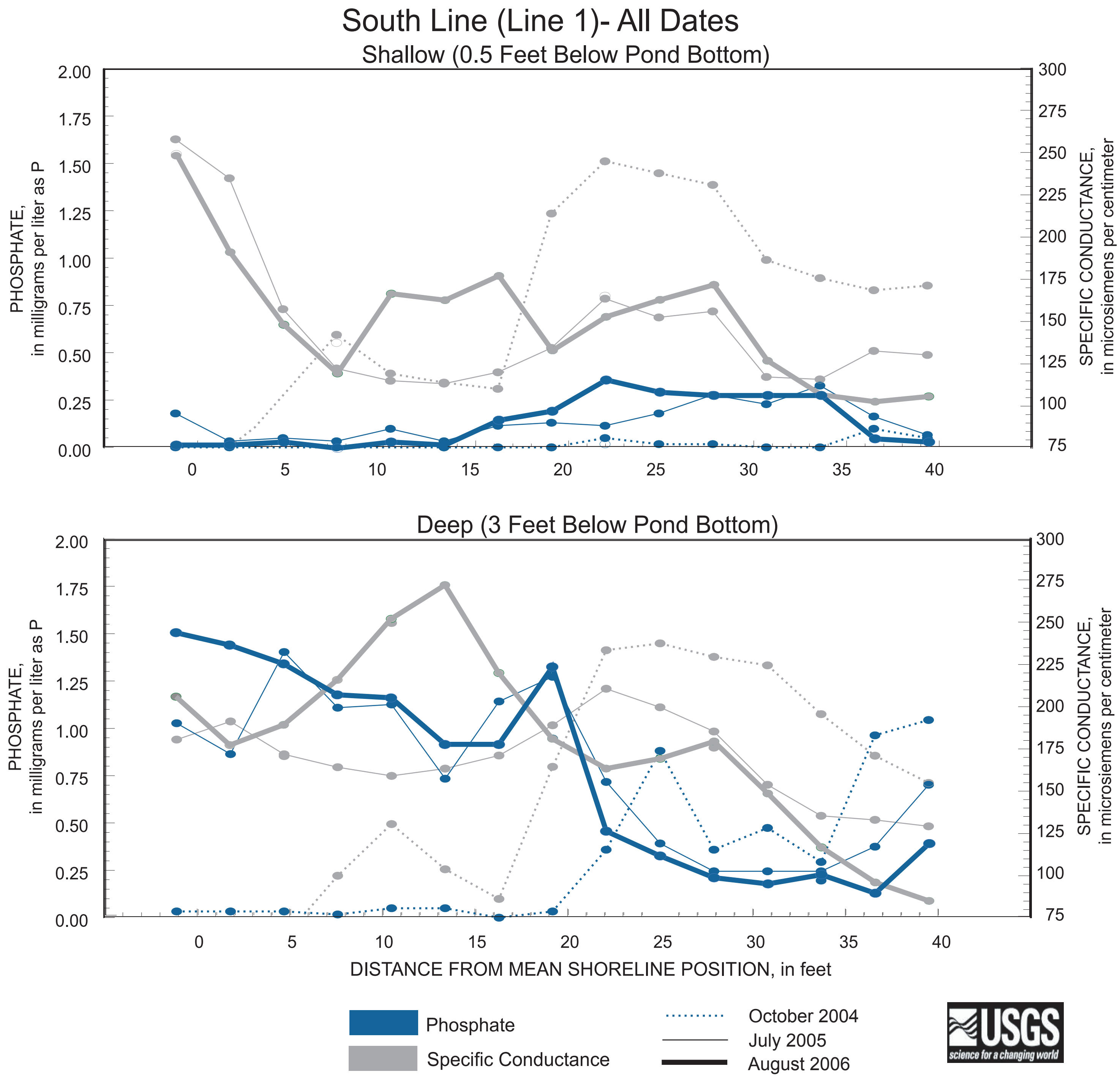


Figure 6a. Geochemical transects from horizontal multilevel samplers along line 1 (south) sampled 2 months (October 2004), 11 months (July 2005), and 23 months (August 2006) after installation of the geochemical barrier.

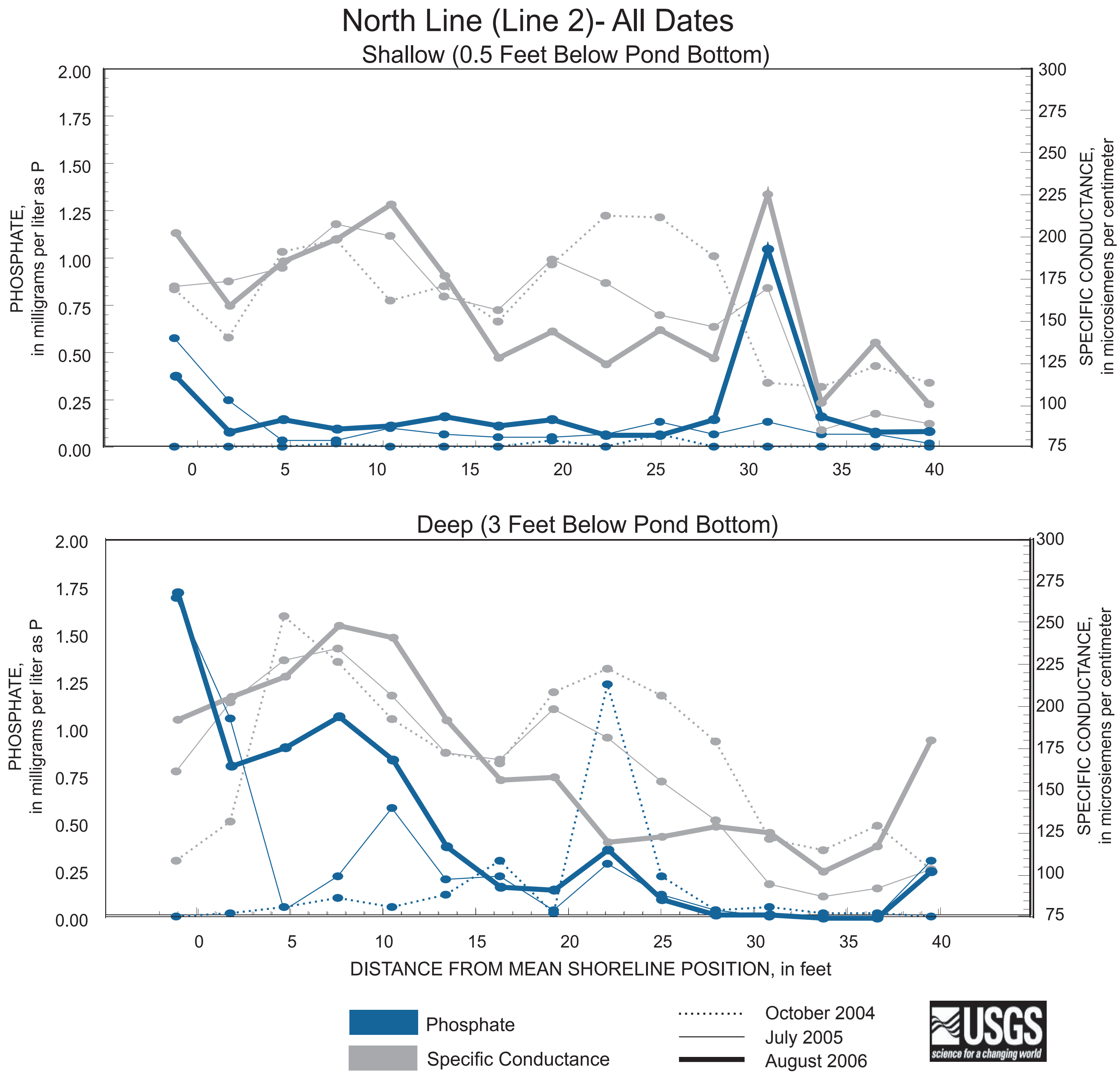


Figure 6b. Geochemical transects from horizontal multilevel samplers along line 2 (north) sampled 2 months (October 2004), 11 months (July 2005), and 23 months (August 2006) after installation of the geochemical barrier.

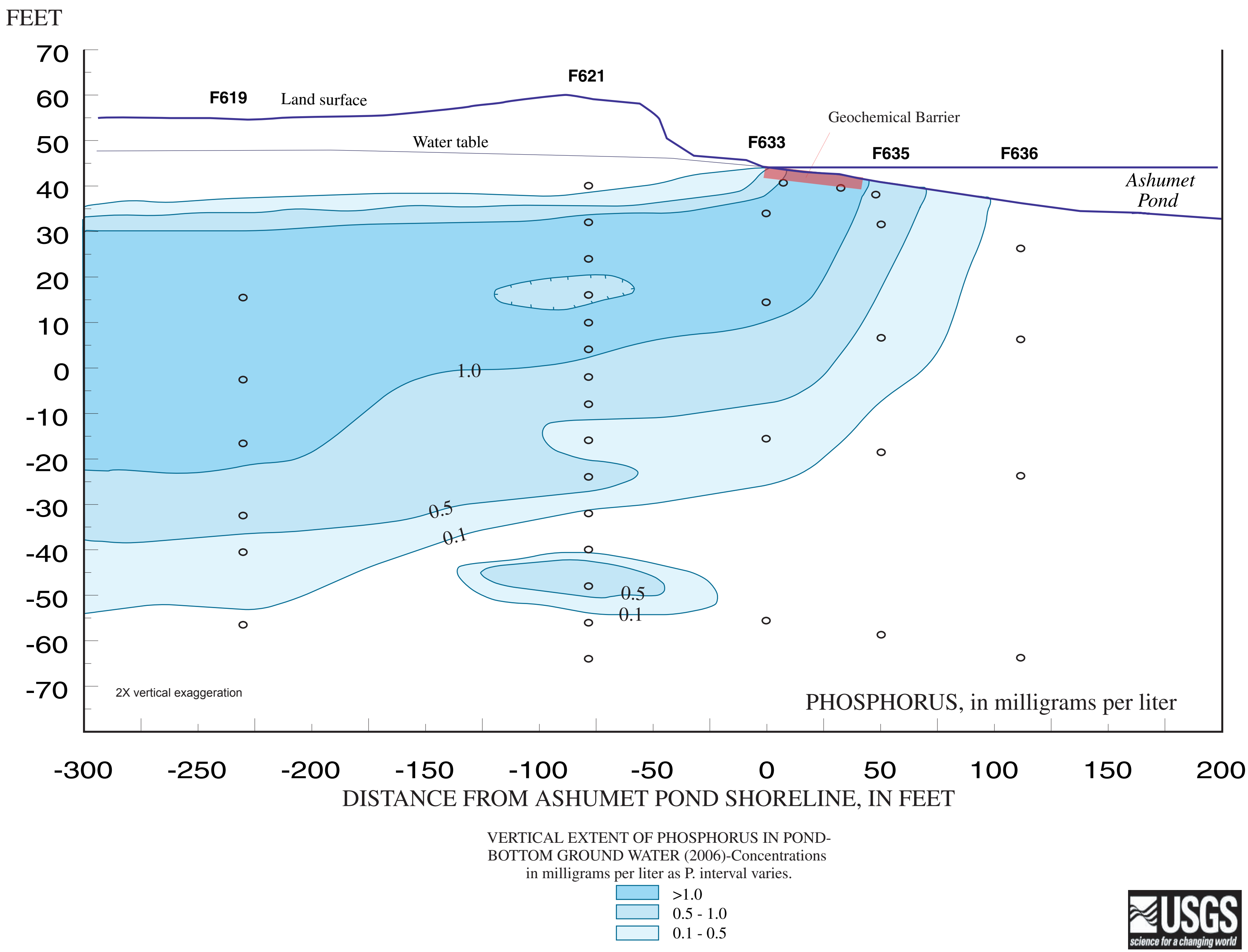


Figure 7a. Vertical section of phosphorus concentrations in piezometer clusters approximately 23 months (August 2006) after installation of the geochemical barrier.

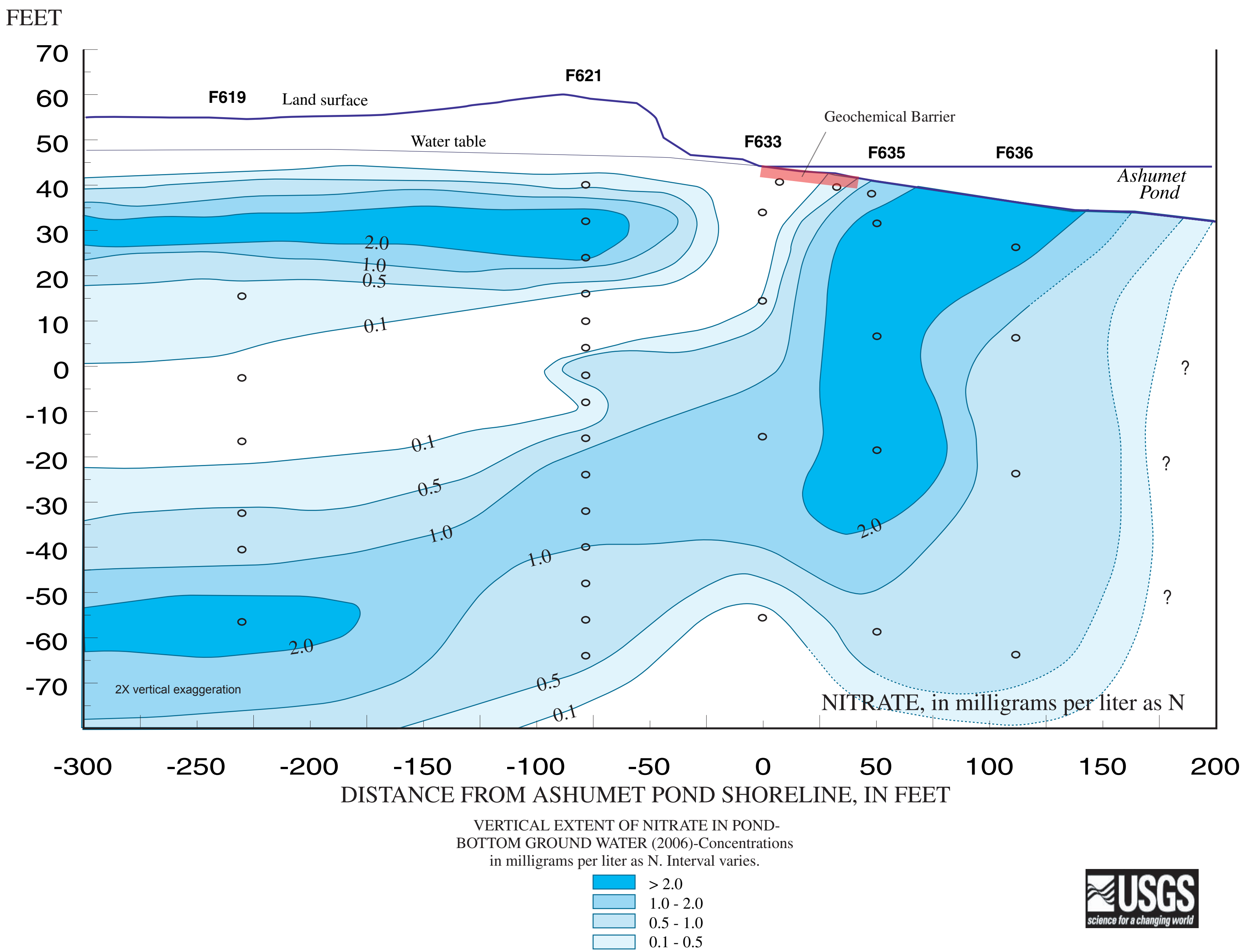


Figure 7b. Vertical section of nitrate concentrations in piezometer clusters approximately 23 months (August 2006) after installation of the geochemical barrier.

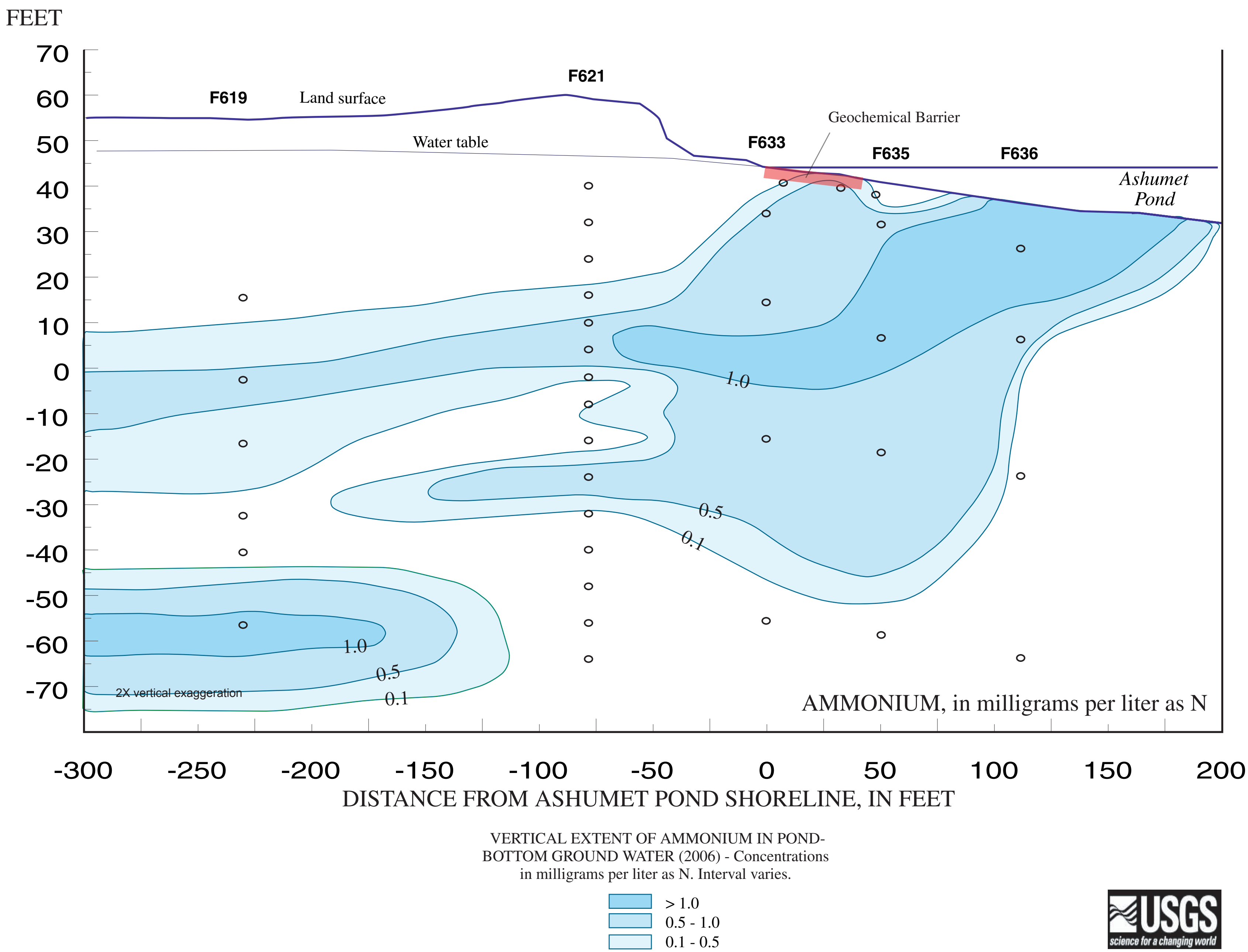


Figure 7c. Vertical section of ammonium concentrations in piezometer clusters approximately 23 months (August 2006) after installation of the geochemical barrier.

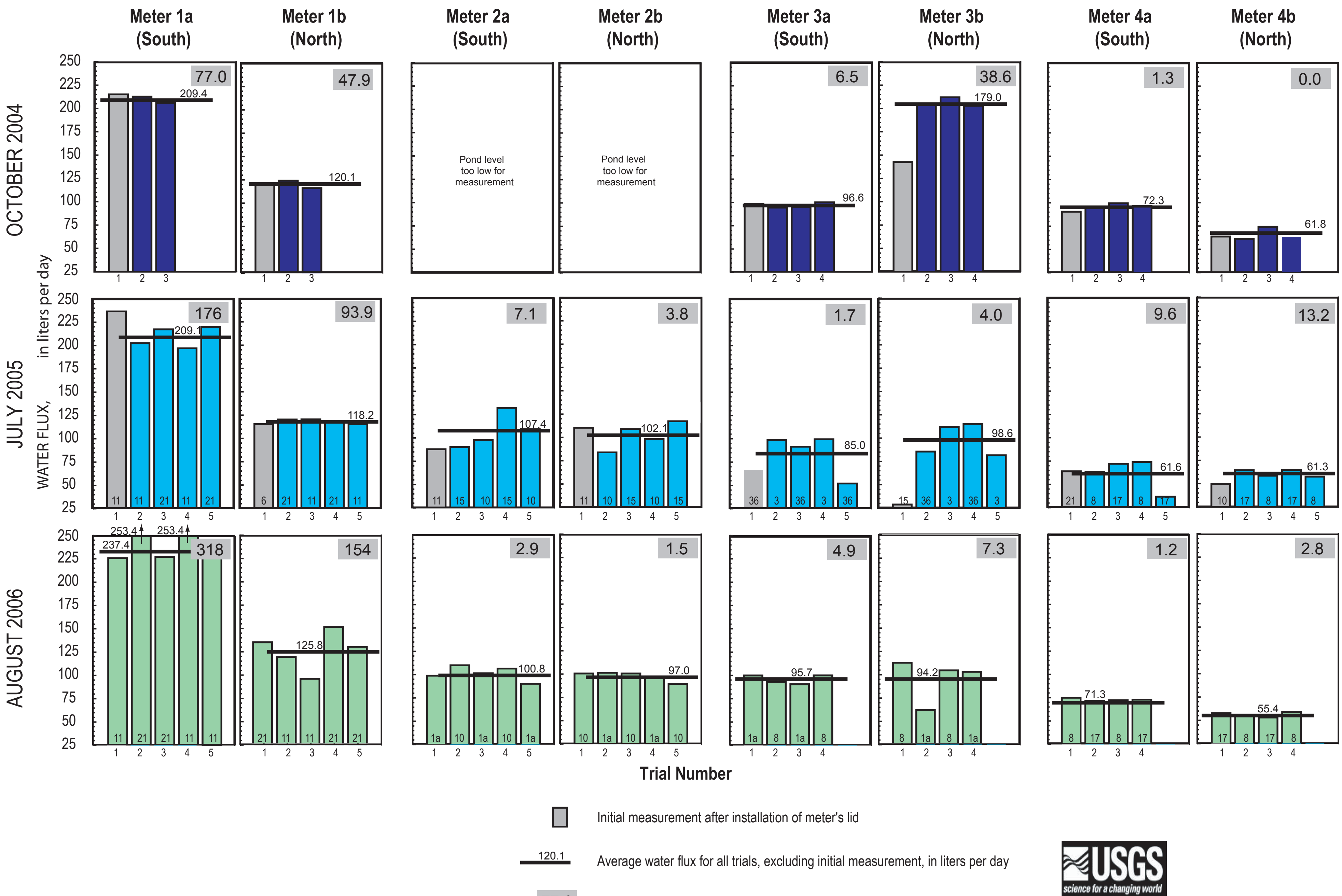


Figure 8. Field seepage data and phosphorus flux analysis for samples collected 2, 11, and 23 months after barrier installation at permanent seepage meters installed near (1a-b) and in (2a-b, 3a-b, 4a-b) the geochemical barrier.

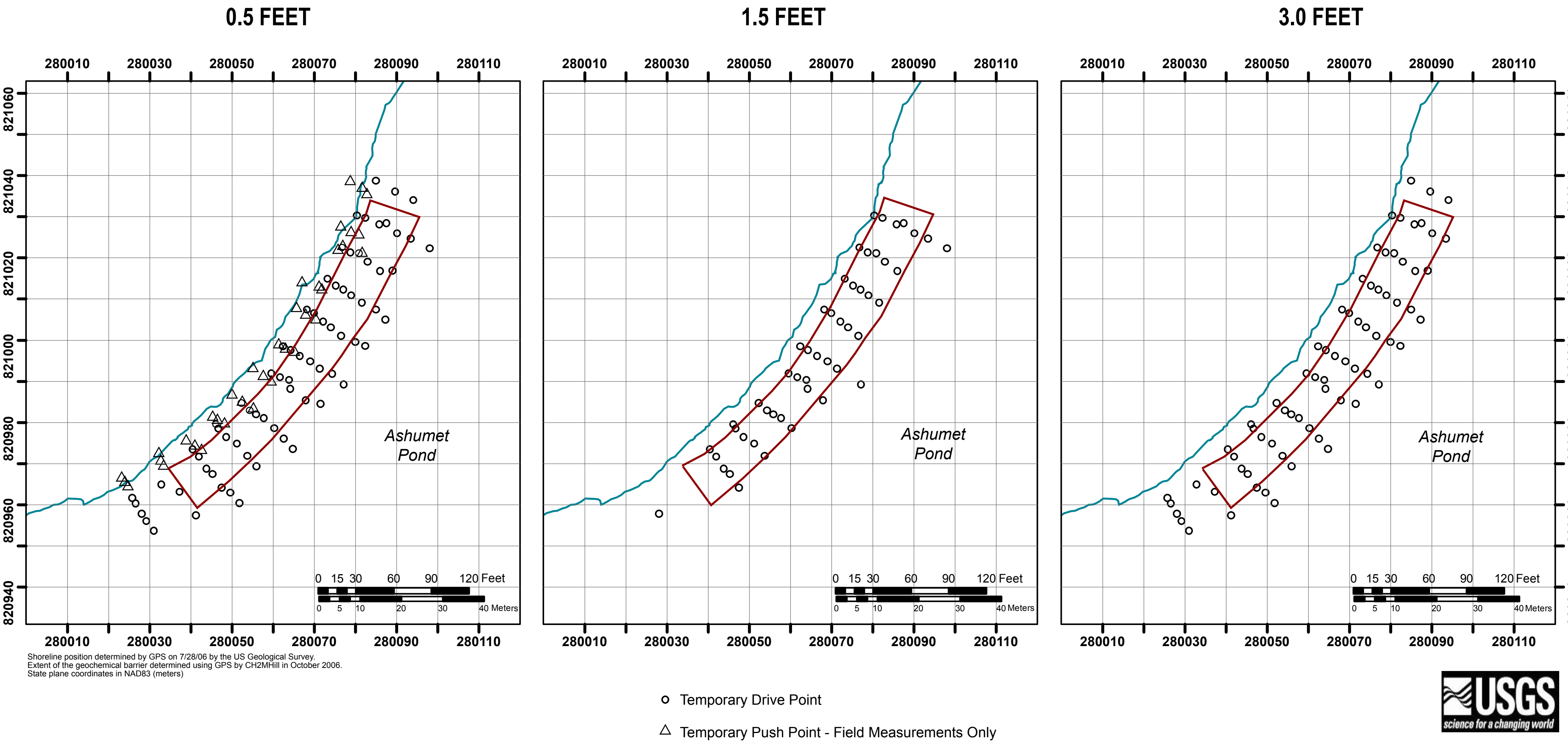


Figure 9a. Locations of temporary drive points installed in August 2006 at three depths (0.5, 1.5, and 3.0 feet) below the pond bottom to monitor ground water below and within the geochemical barrier at Ashumet Pond.

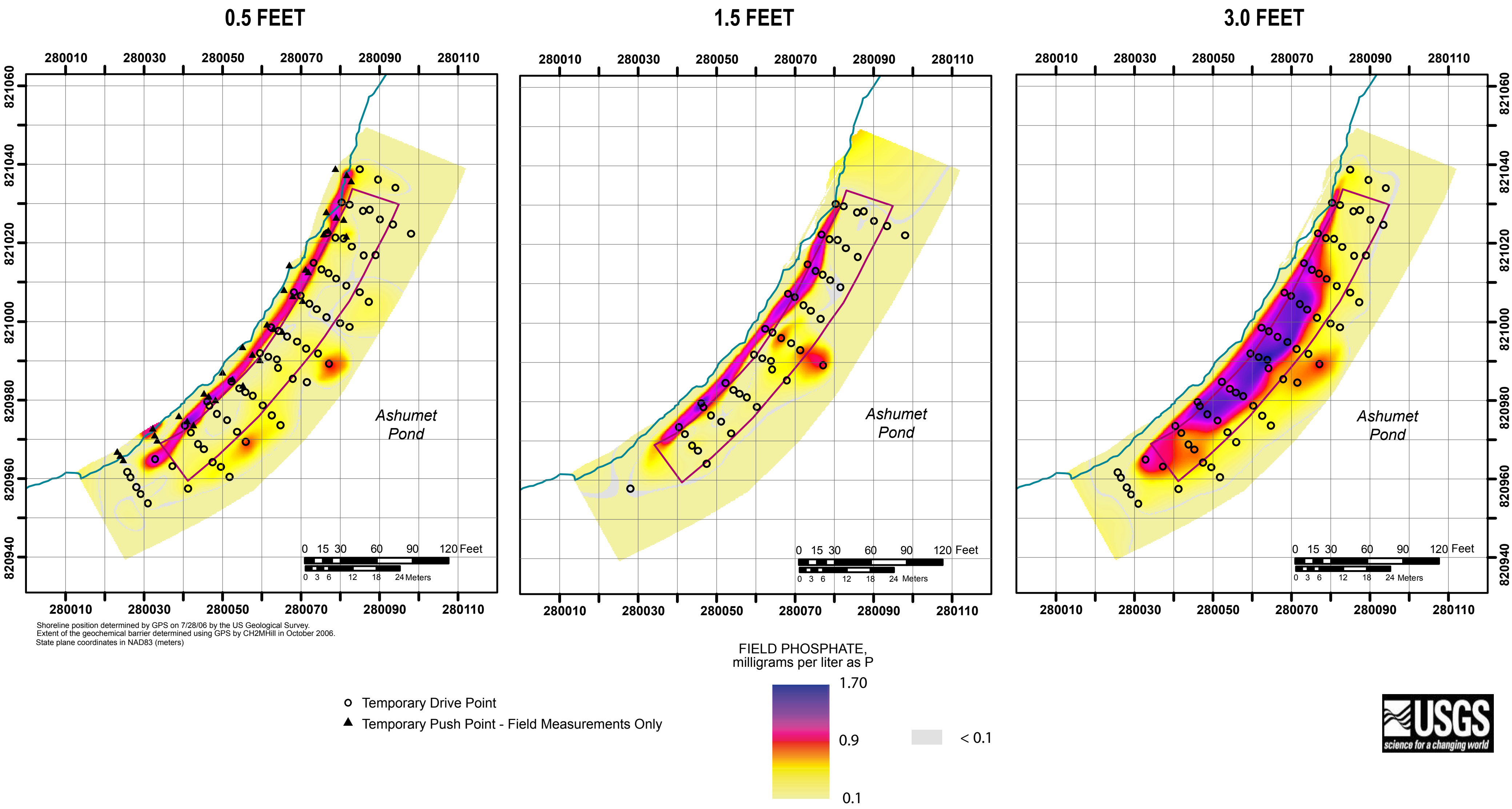
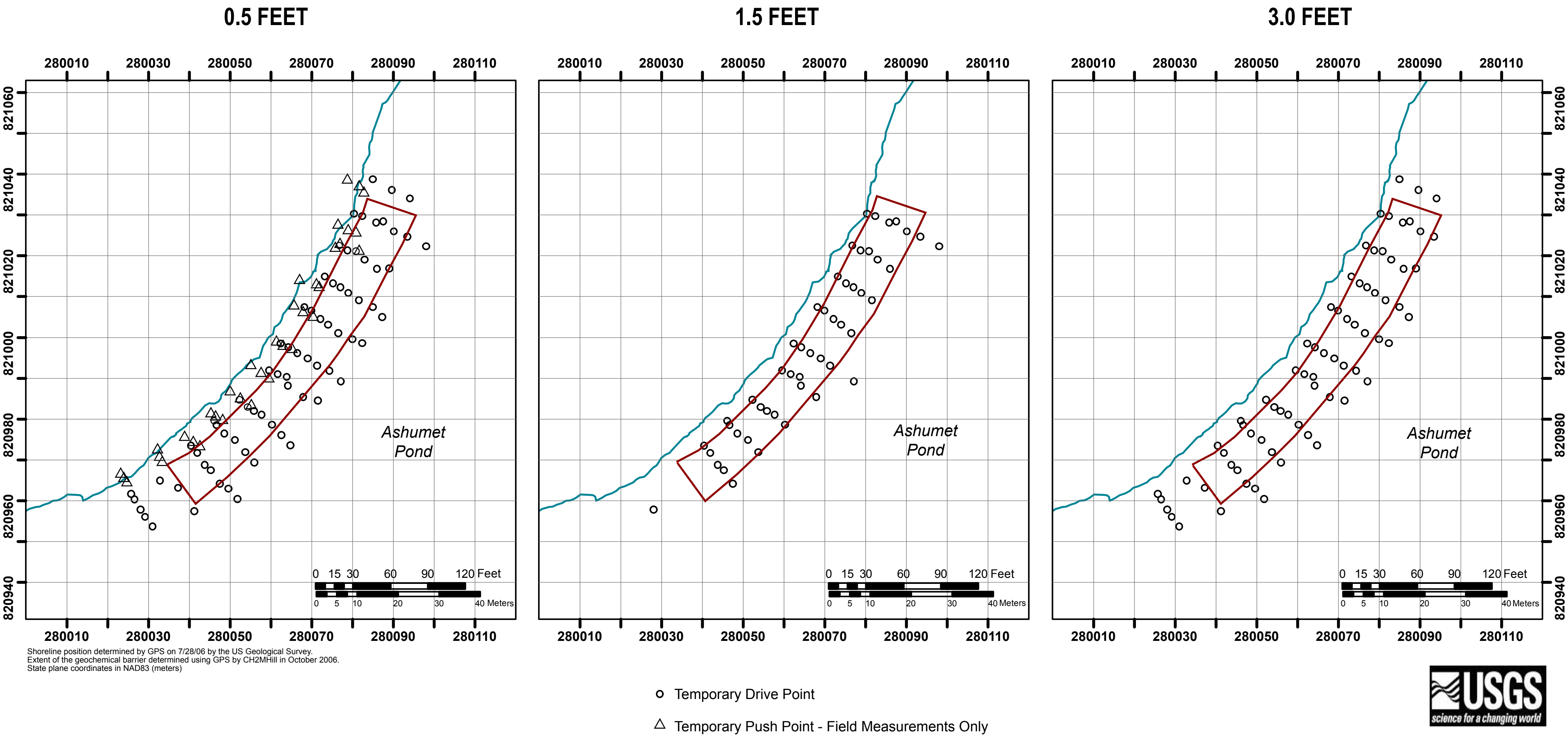


Figure 9f. Map showing distribution of field phosphate in August 2006 in pond-bottom ground water at three depths below and within the geochemical barrier at Ashumet Pond. The maps are generated from hand-contours using a geographic information system (GIS).



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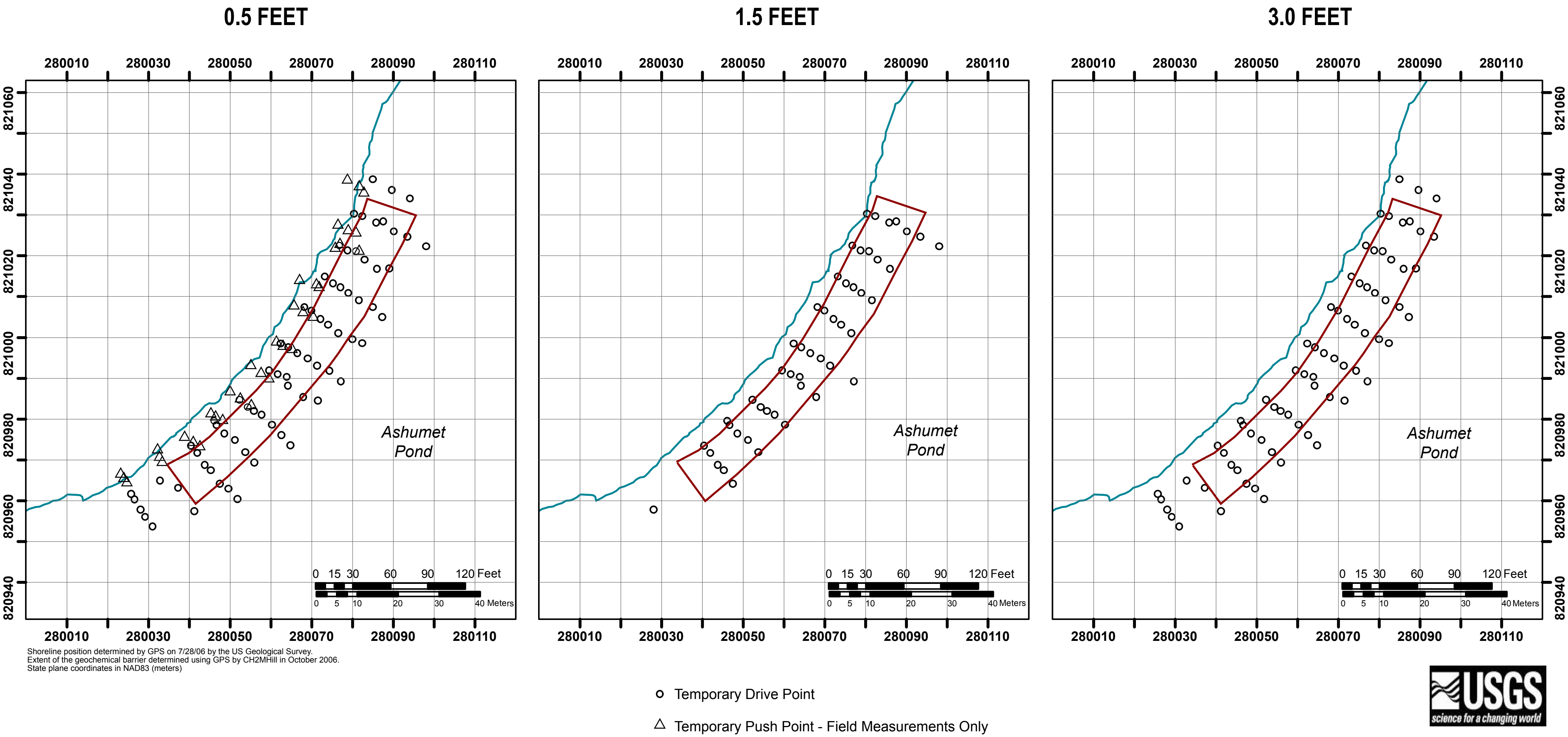

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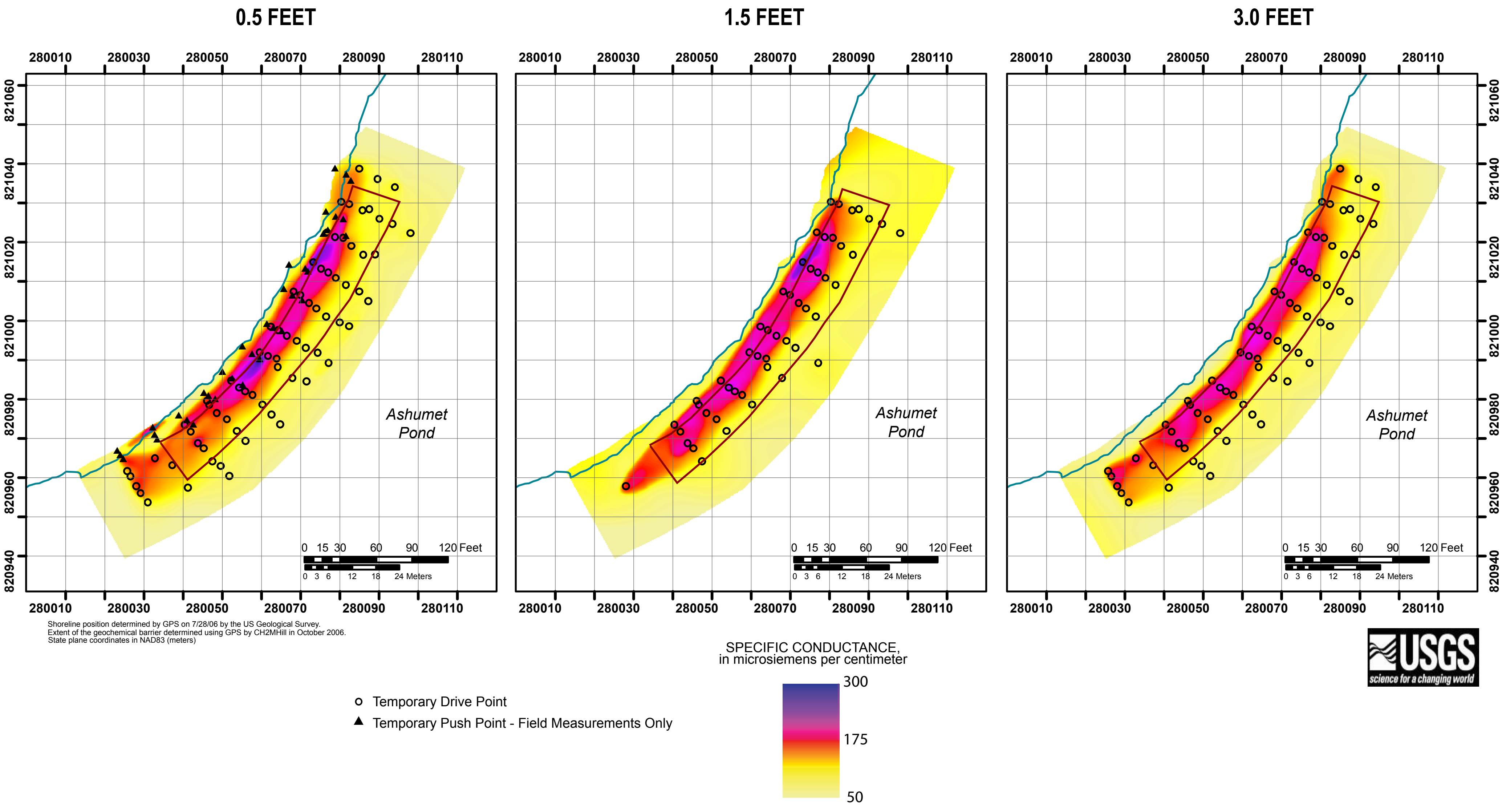


Figure 9b. Map showing distribution of specific conductance in August 2006 in pond-bottom ground water at three depths below and within the geochemical barrier at Ashumet Pond. The maps are generated from hand-contours using a geographic information system (GIS).

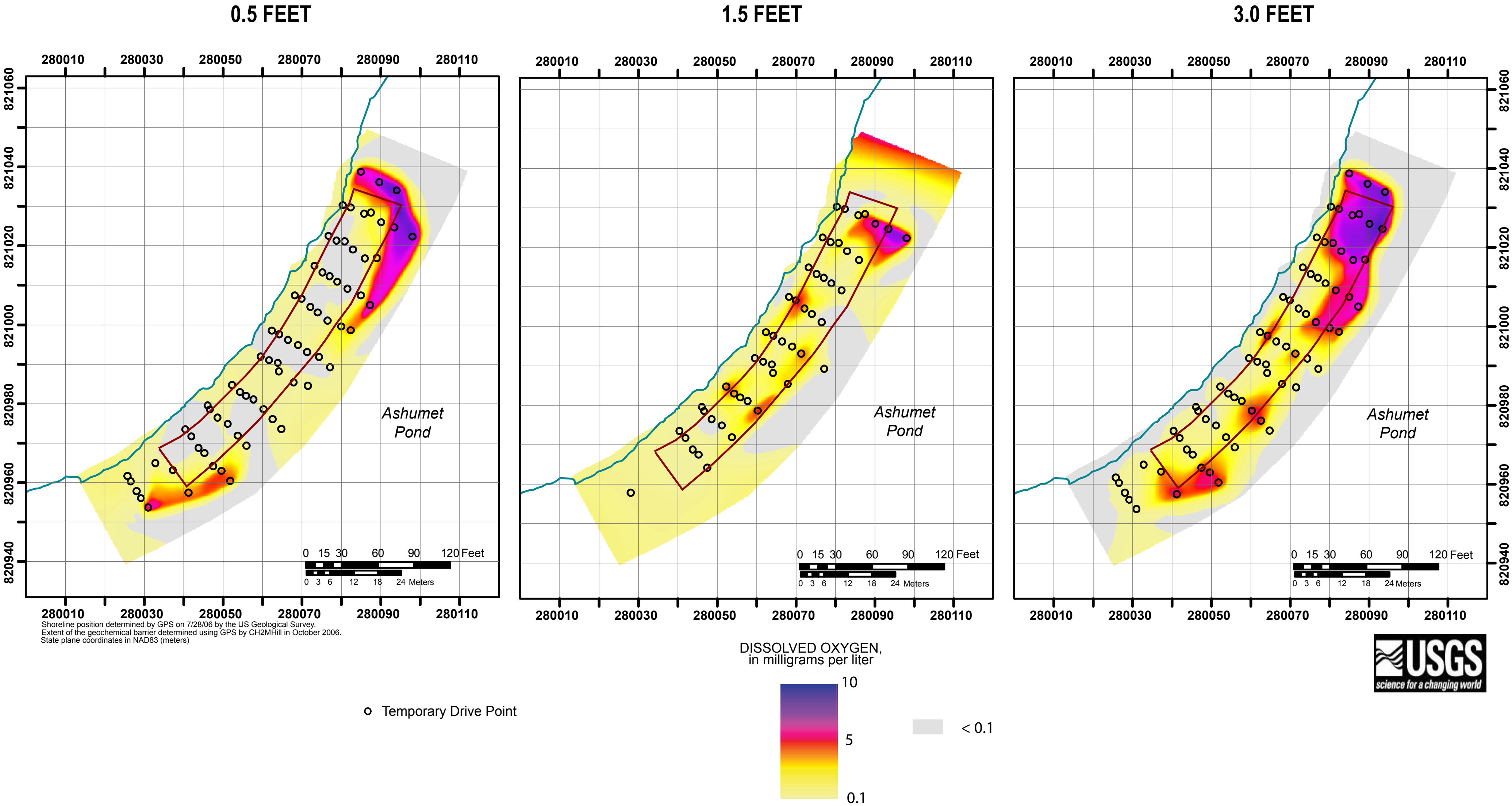


Figure 9c. Map showing distribution of dissolved oxygen in August 2006 in pond-bottom ground water at three depths below and within the geochemical barrier at Ashumet Pond. The maps are generated from hand-contours using a geographic information system (GIS).

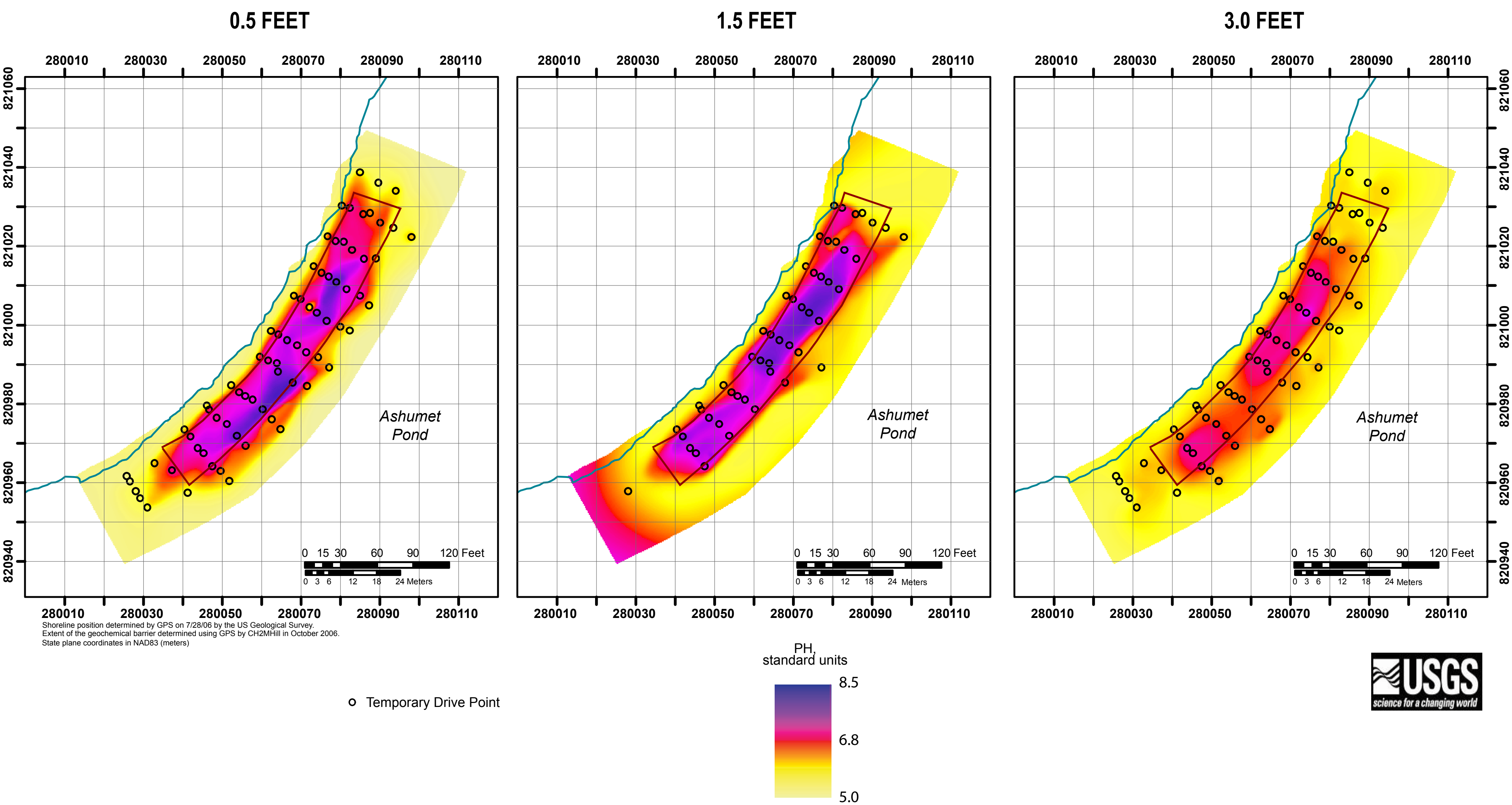


Figure 9d. Map showing distribution of pH in August 2006 in pond-bottom ground water at three depths below and within the geochemical barrier at Ashumet Pond. The maps are generated from hand-contours using a geographic information system (GIS).

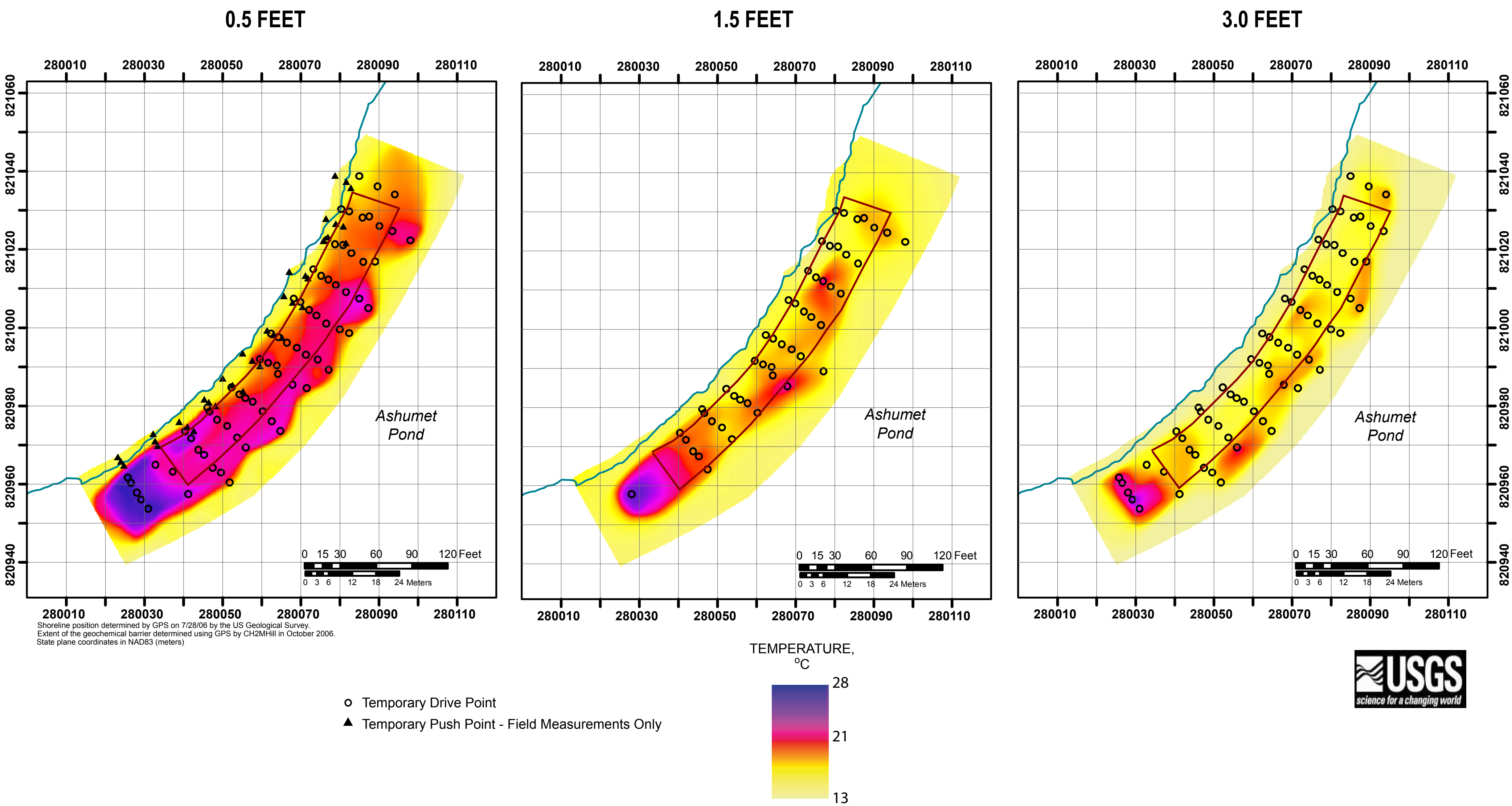


Figure 9e. Map showing distribution of temperature in August 2006 in pond-bottom ground water at three depths below and within the geochemical barrier at Ashumet Pond. The maps are generated from hand-contours using a geographic information system (GIS).

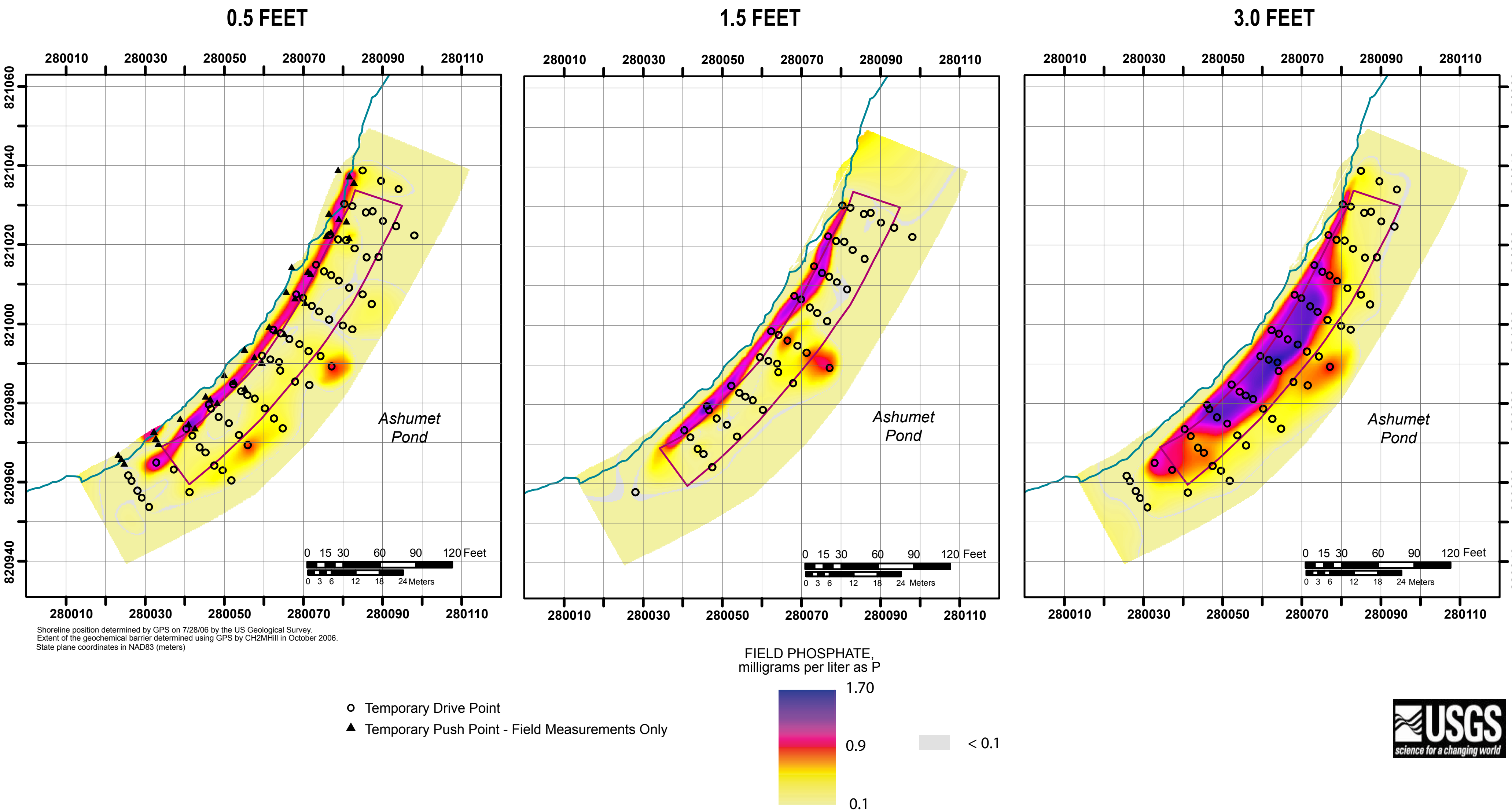


Figure 9f. Map showing distribution of field phosphate in August 2006 in pond-bottom ground water at three depths below and within the geochemical barrier at Ashumet Pond. The maps are generated from hand-contours using a geographic information system (GIS).

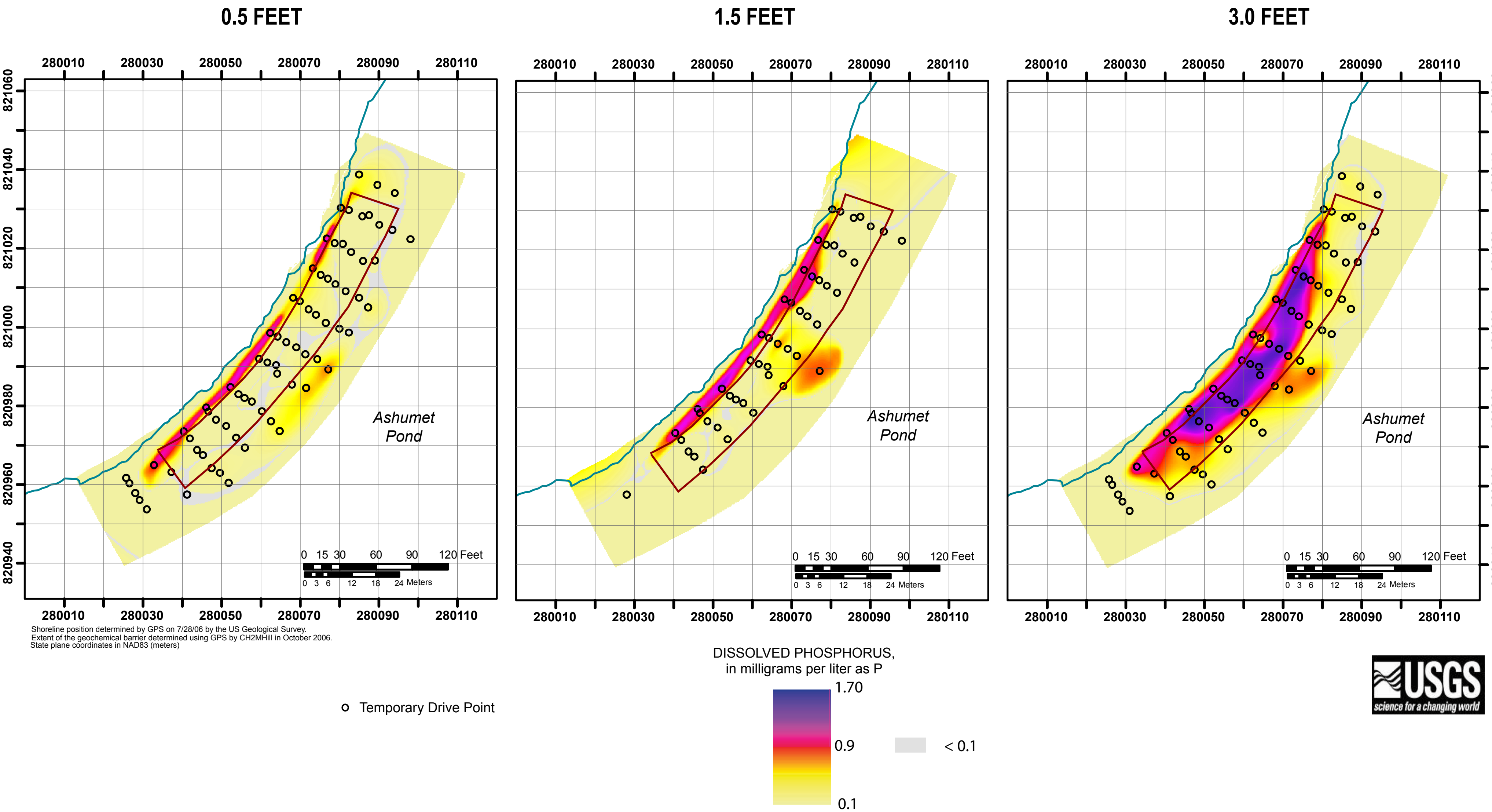


Figure 9g. Map showing distribution of dissolved phosphorus in August 2006 in pond-bottom ground water at three depths below and within the geochemical barrier at Ashumet Pond. The maps are generated from hand-contours using a geographic information system (GIS).

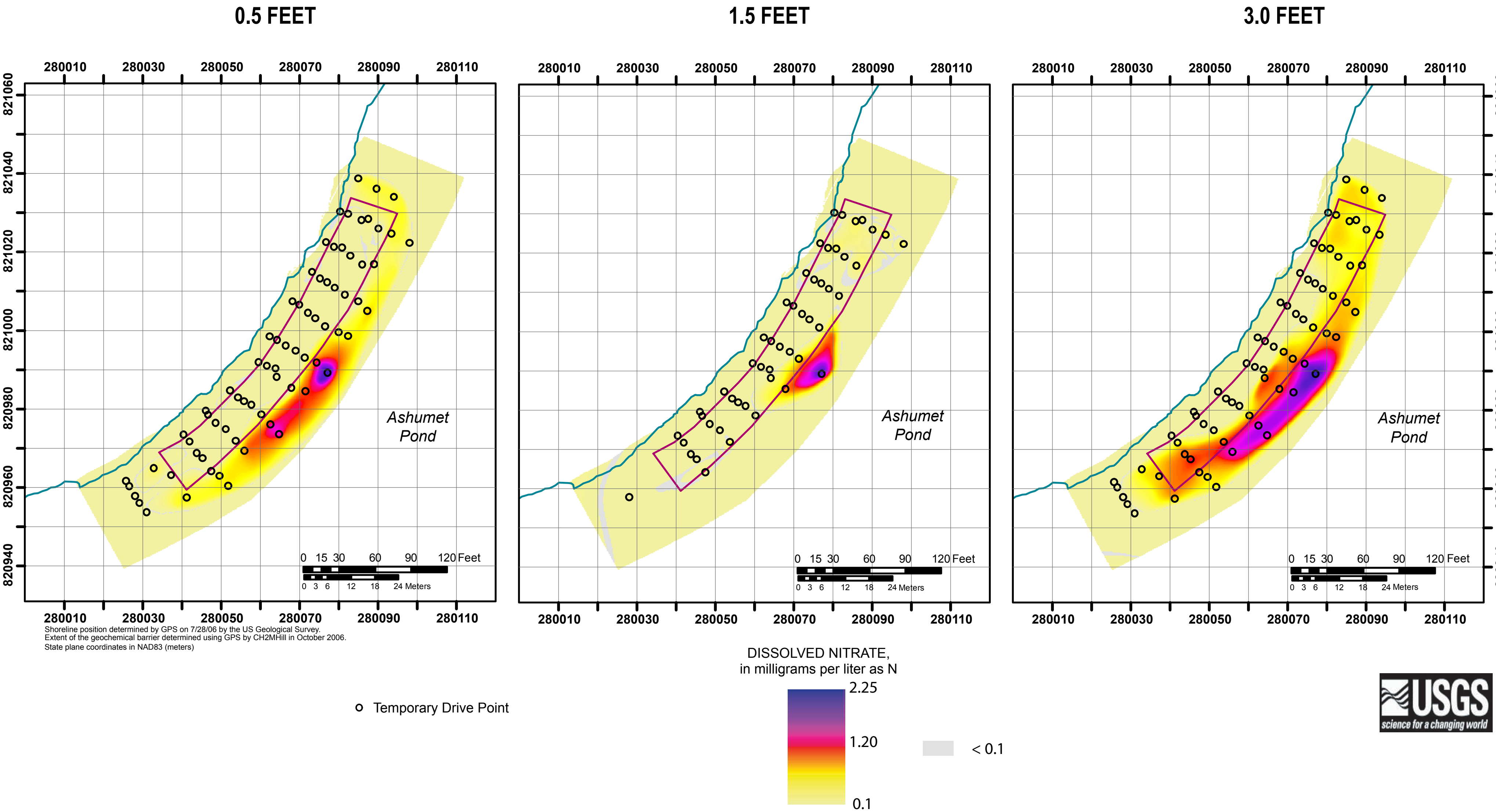


Figure 9h. Map showing distribution of dissolved nitrate in August 2006 in pond-bottom ground water at three depths below and within the geochemical barrier at Ashumet Pond. The maps are generated from hand-contours using a geographic information system (GIS).

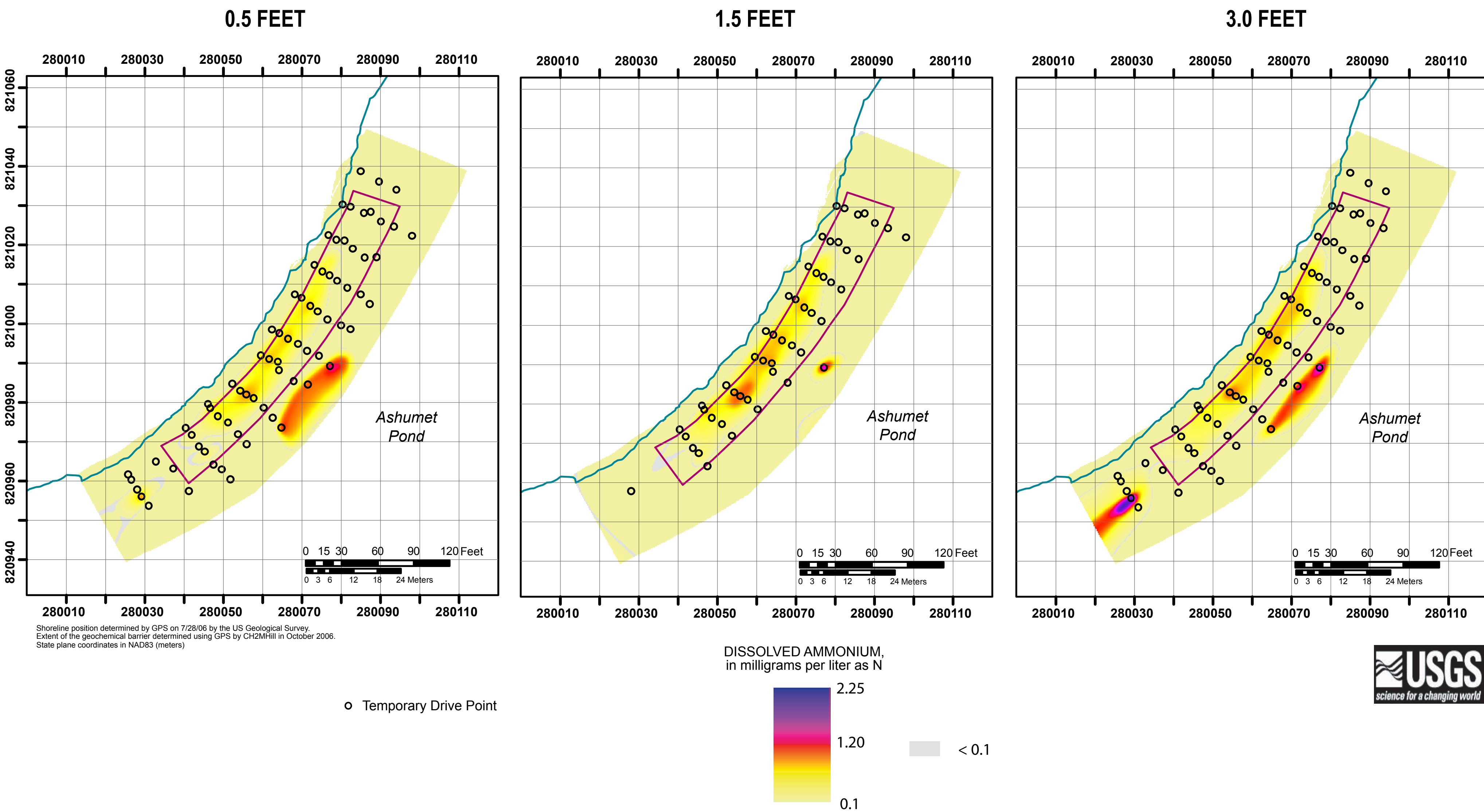


Figure 9i. Map showing distribution of dissolved ammonium in August 2006 in pond-bottom ground water at three depths below and within the geochemical barrier at Ashumet Pond. The maps are generated from hand-contours using a geographic information system (GIS).

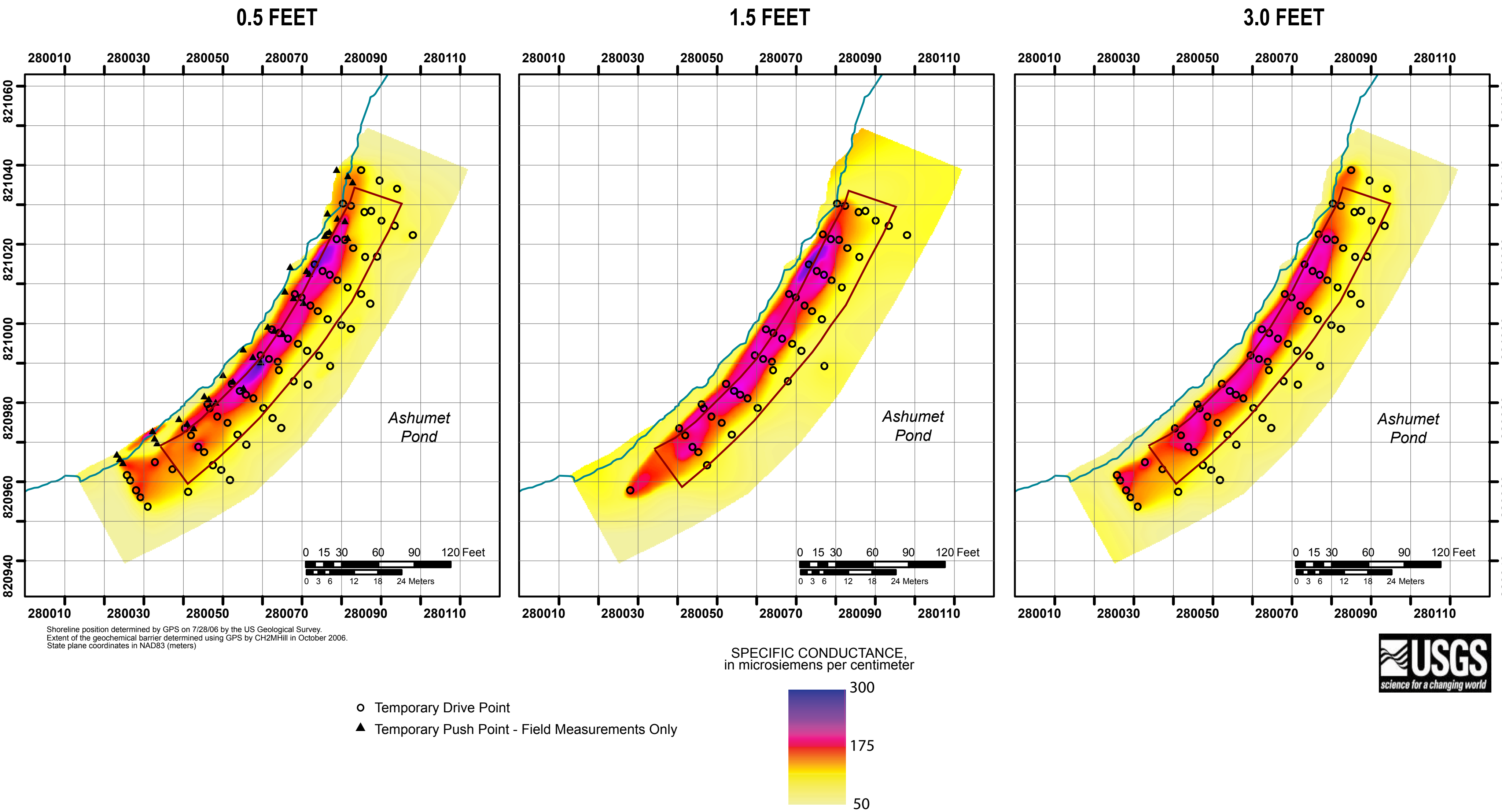


Figure 9b. Map showing distribution of specific conductance in August 2006 in pond-bottom ground water at three depths below and within the geochemical barrier at Ashumet Pond. The maps are generated from hand-contours using a geographic information system (GIS).

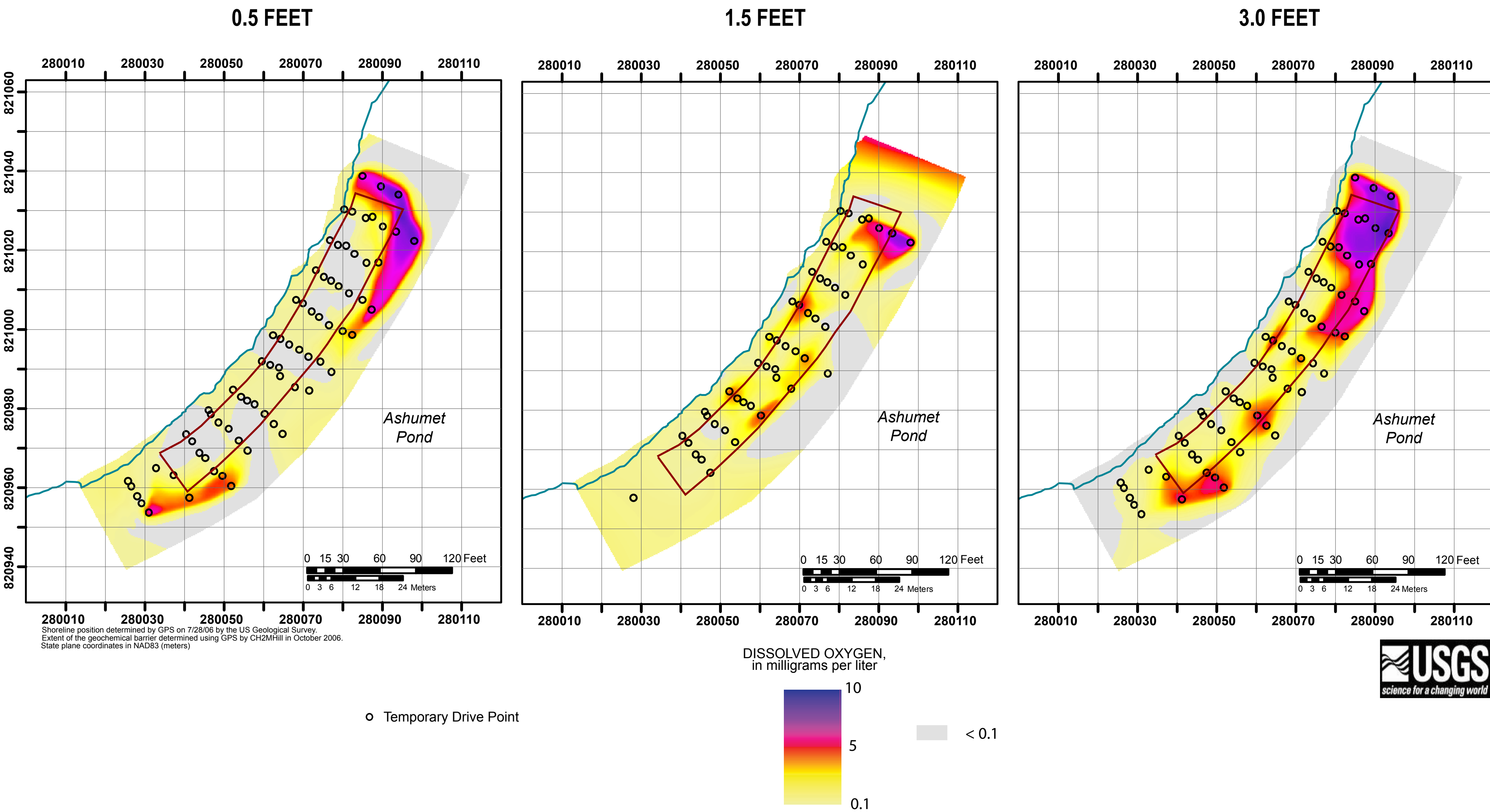


Figure 9c. Map showing distribution of dissolved oxygen in August 2006 in pond-bottom ground water at three depths below and within the geochemical barrier at Ashumet Pond. The maps are generated from hand-contours using a geographic information system (GIS).

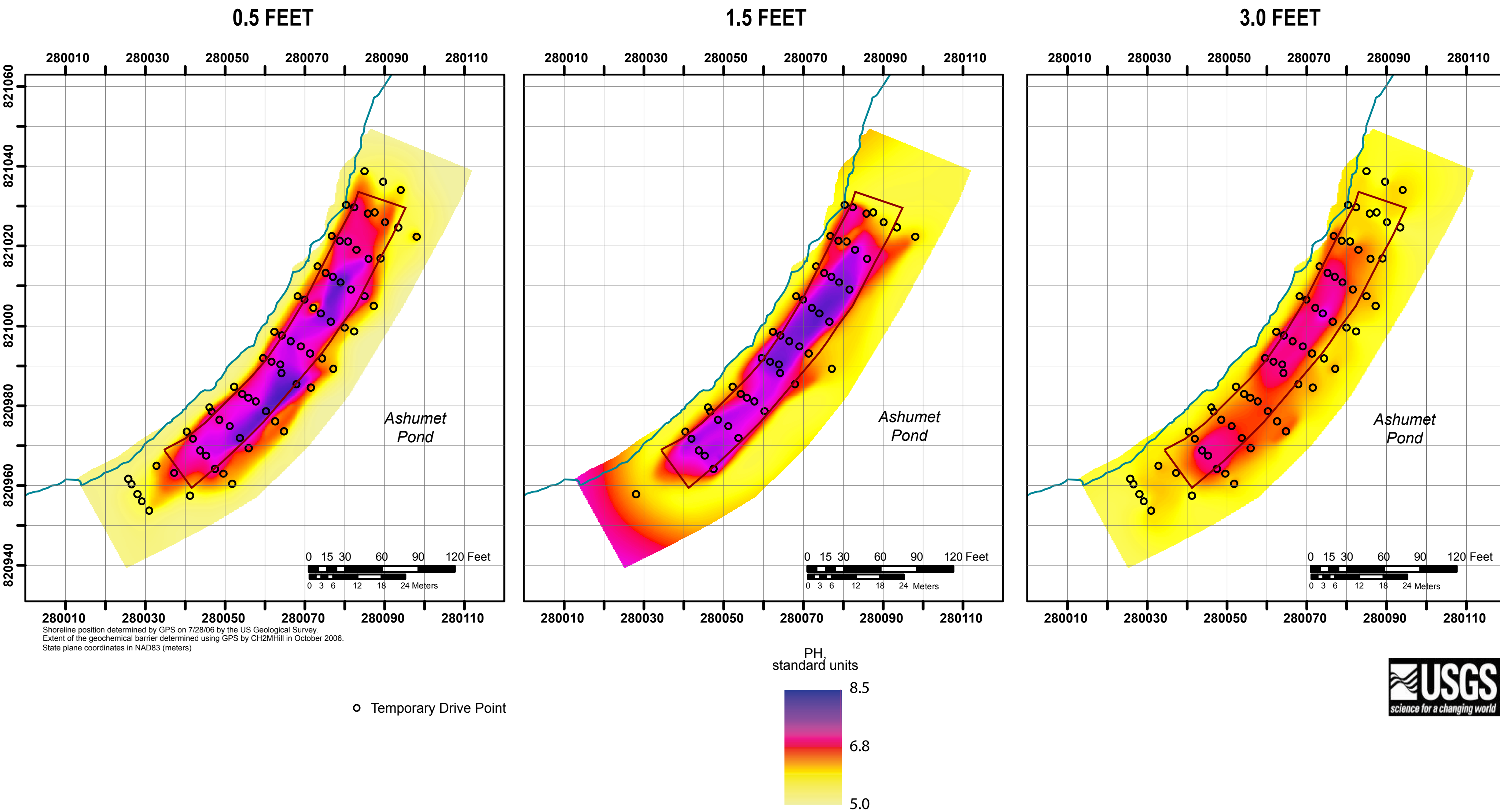


Figure 9d. Map showing distribution of pH in August 2006 in pond-bottom ground water at three depths below and within the geochemical barrier at Ashumet Pond. The maps are generated from hand-contours using a geographic information system (GIS).

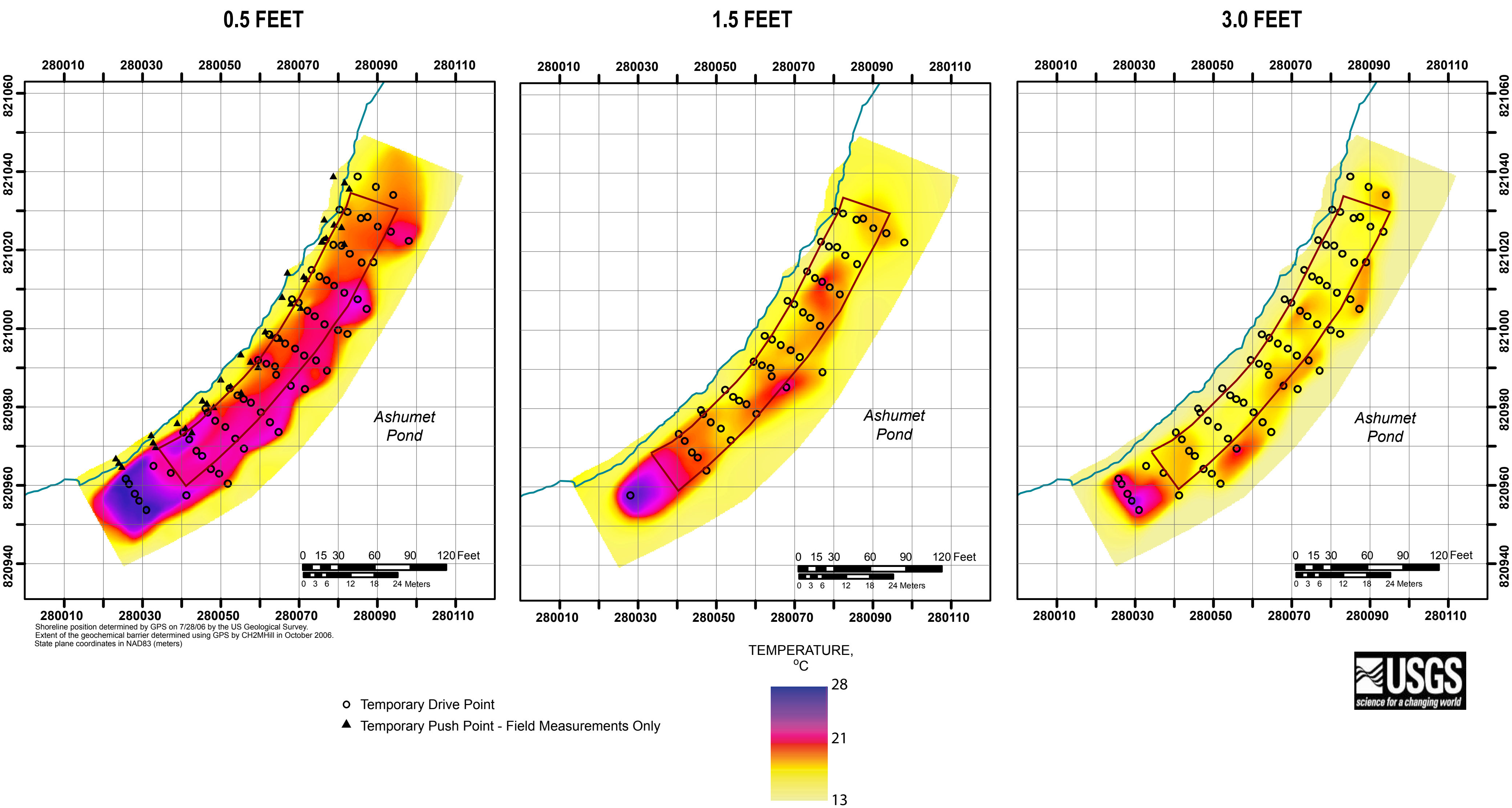


Figure 9e. Map showing distribution of temperature in August 2006 in pond-bottom ground water at three depths below and within the geochemical barrier at Ashumet Pond. The maps are generated from hand-contours using a geographic information system (GIS).

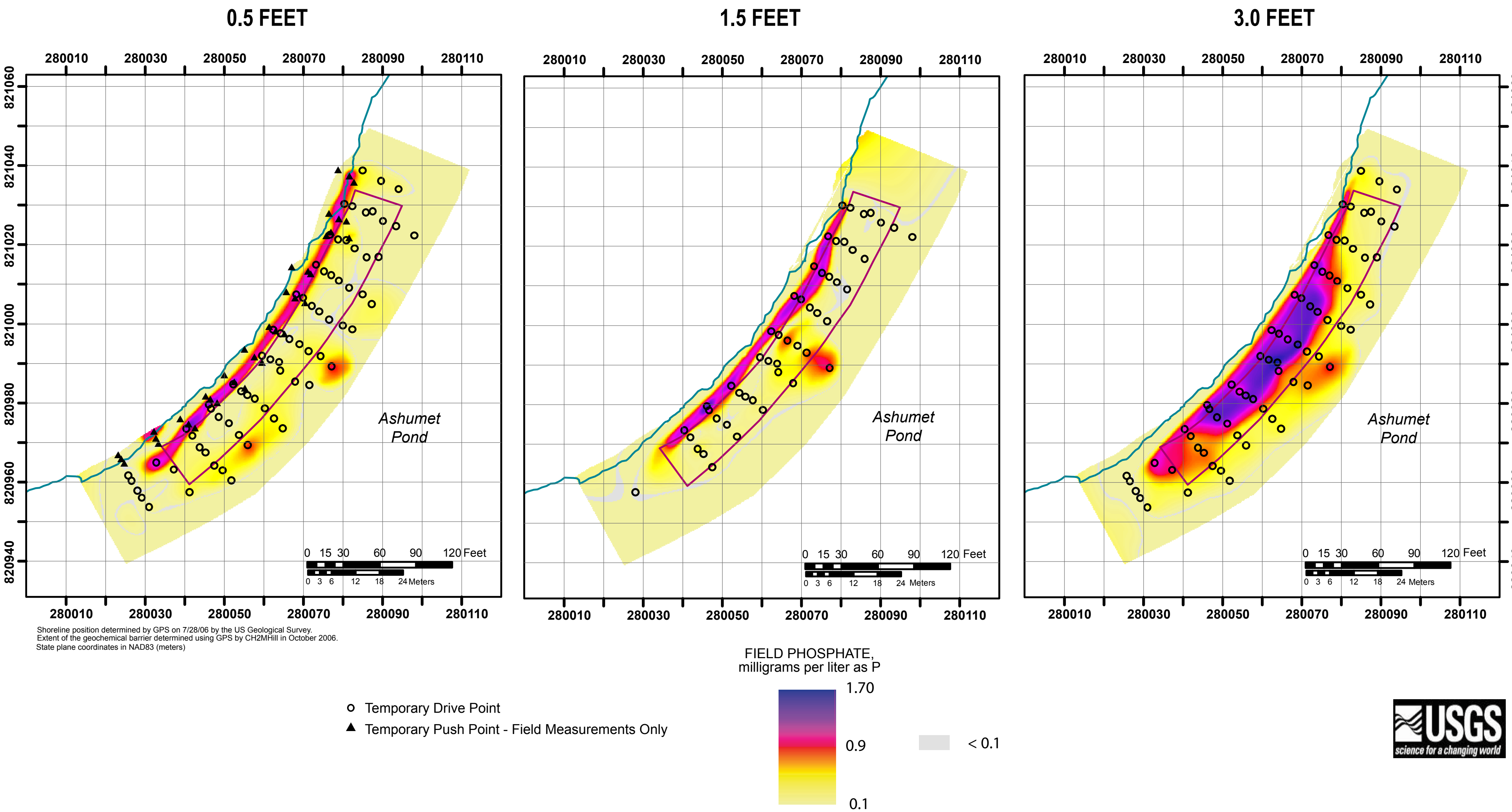


Figure 9f. Map showing distribution of field phosphate in August 2006 in pond-bottom ground water at three depths below and within the geochemical barrier at Ashumet Pond. The maps are generated from hand-contours using a geographic information system (GIS).

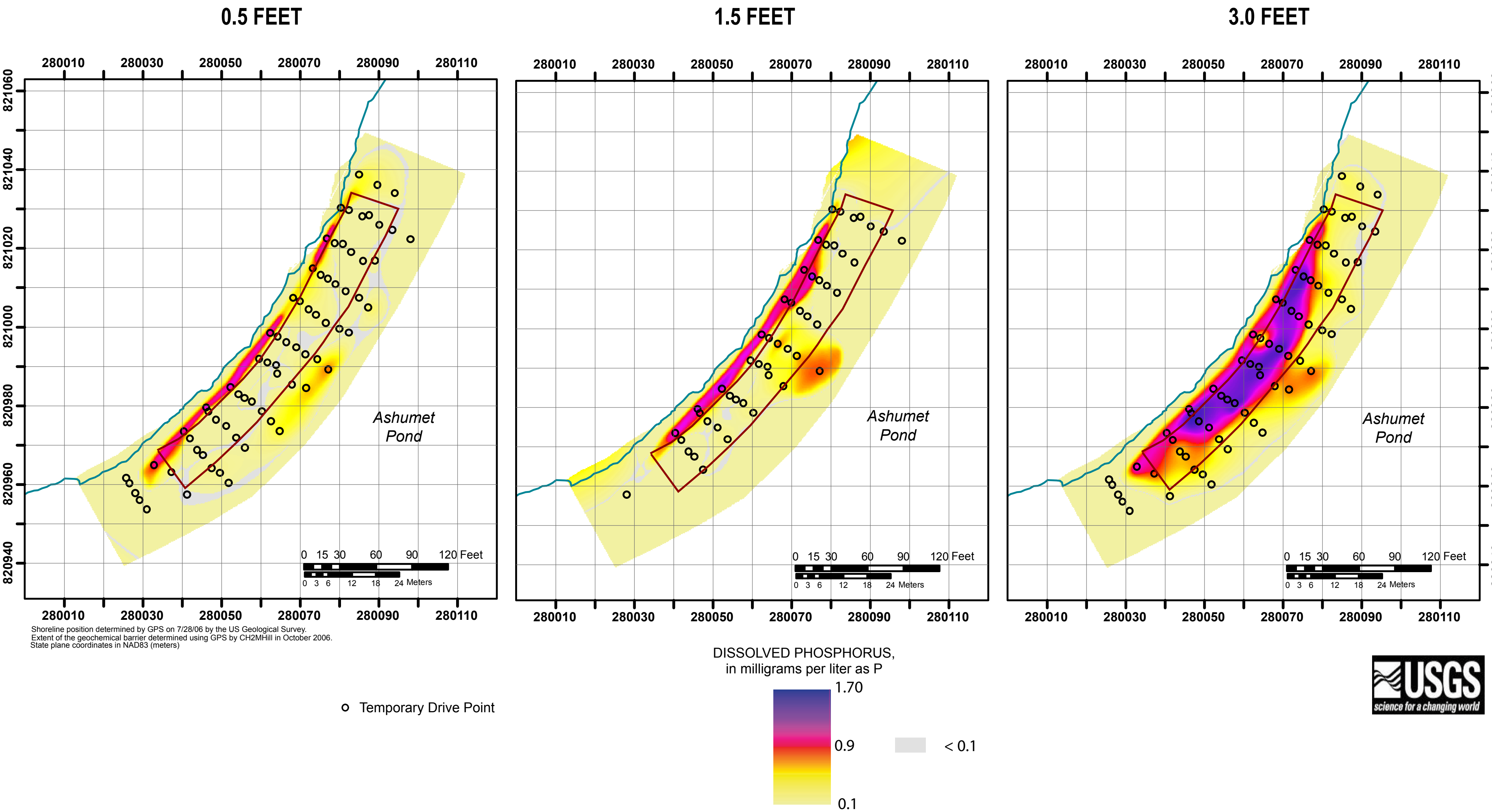


Figure 9g. Map showing distribution of dissolved phosphorus in August 2006 in pond-bottom ground water at three depths below and within the geochemical barrier at Ashumet Pond. The maps are generated from hand-contours using a geographic information system (GIS).

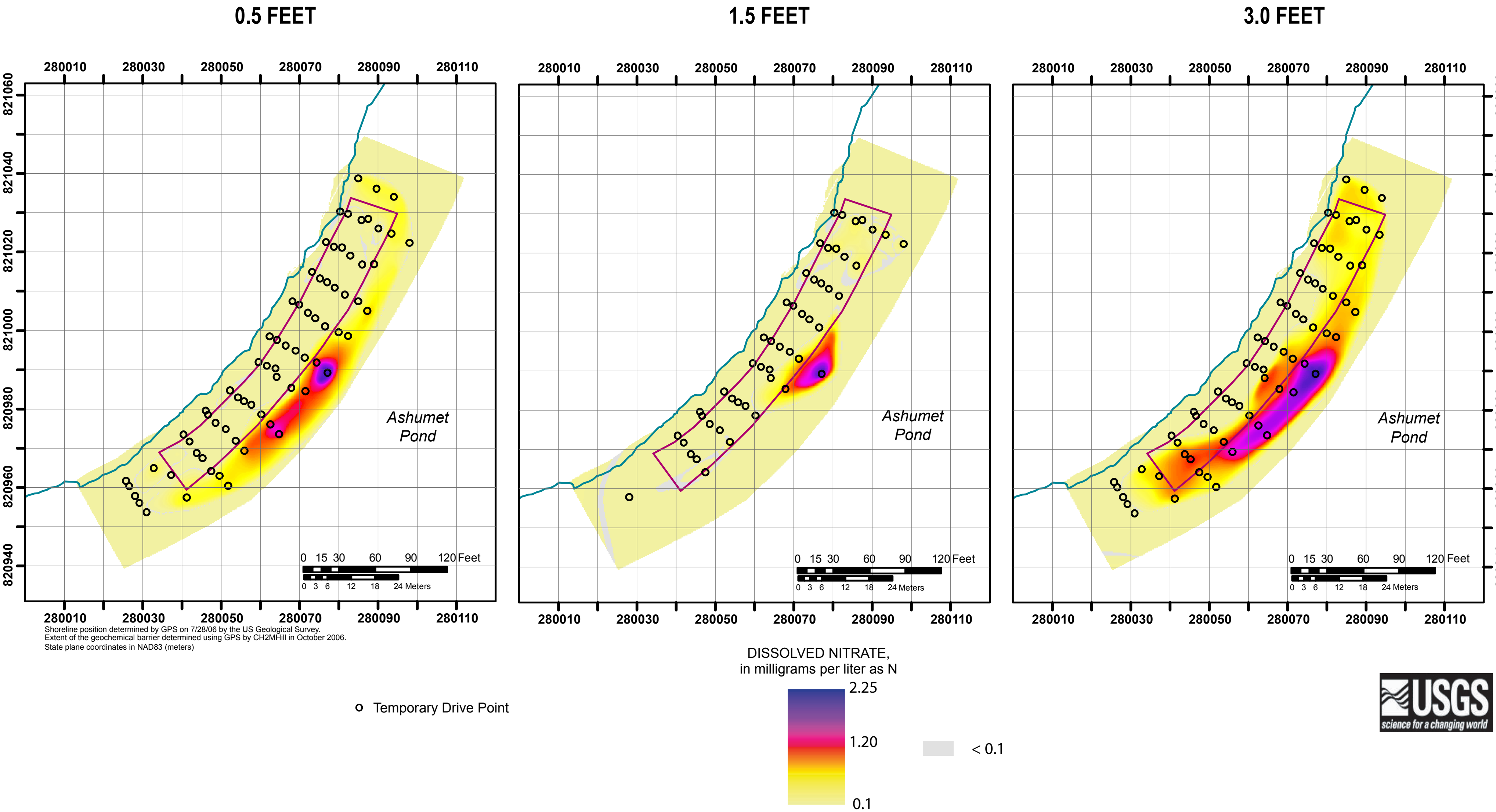


Figure 9h. Map showing distribution of dissolved nitrate in August 2006 in pond-bottom ground water at three depths below and within the geochemical barrier at Ashumet Pond. The maps are generated from hand-contours using a geographic information system (GIS).

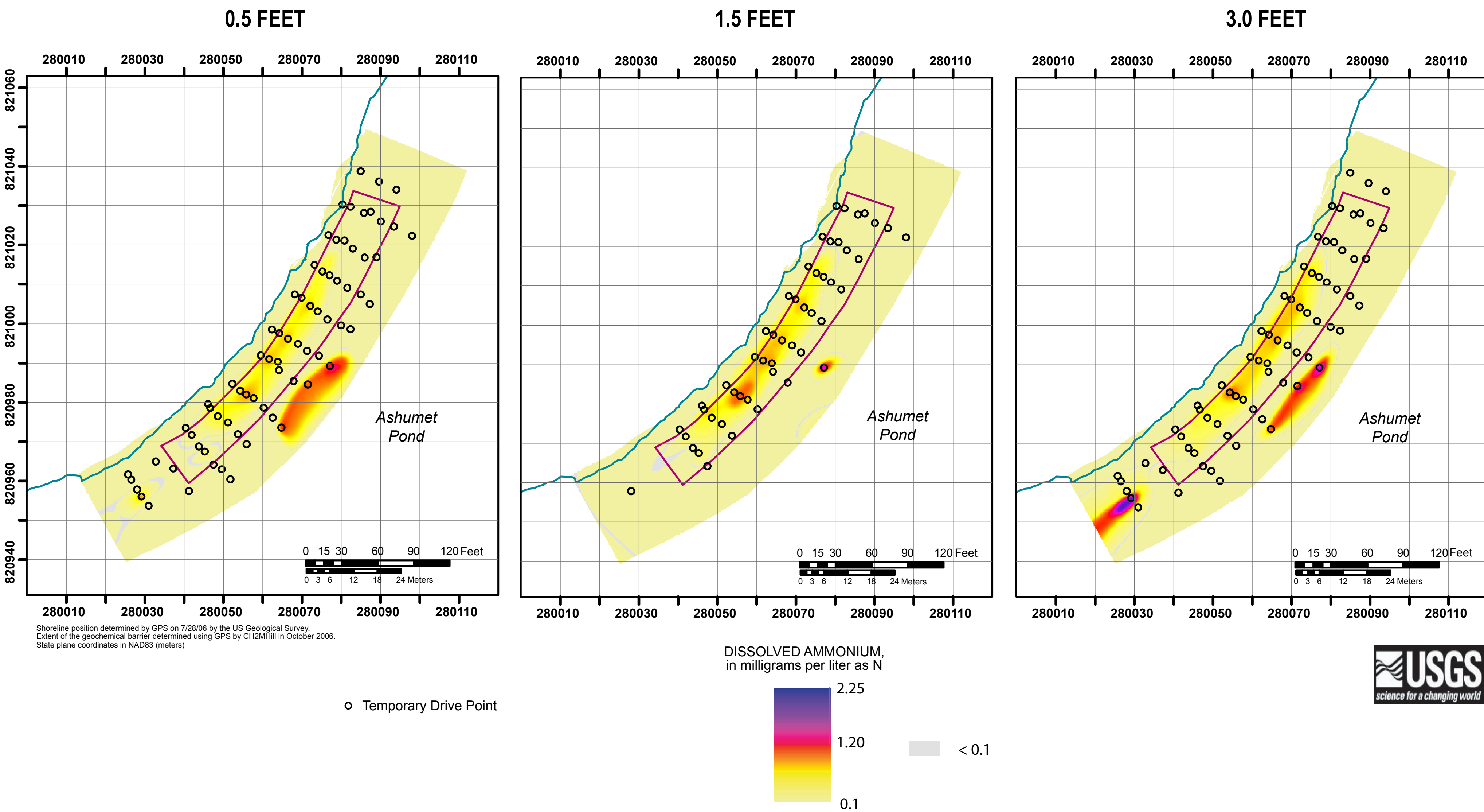


Figure 9i. Map showing distribution of dissolved ammonium in August 2006 in pond-bottom ground water at three depths below and within the geochemical barrier at Ashumet Pond. The maps are generated from hand-contours using a geographic information system (GIS).

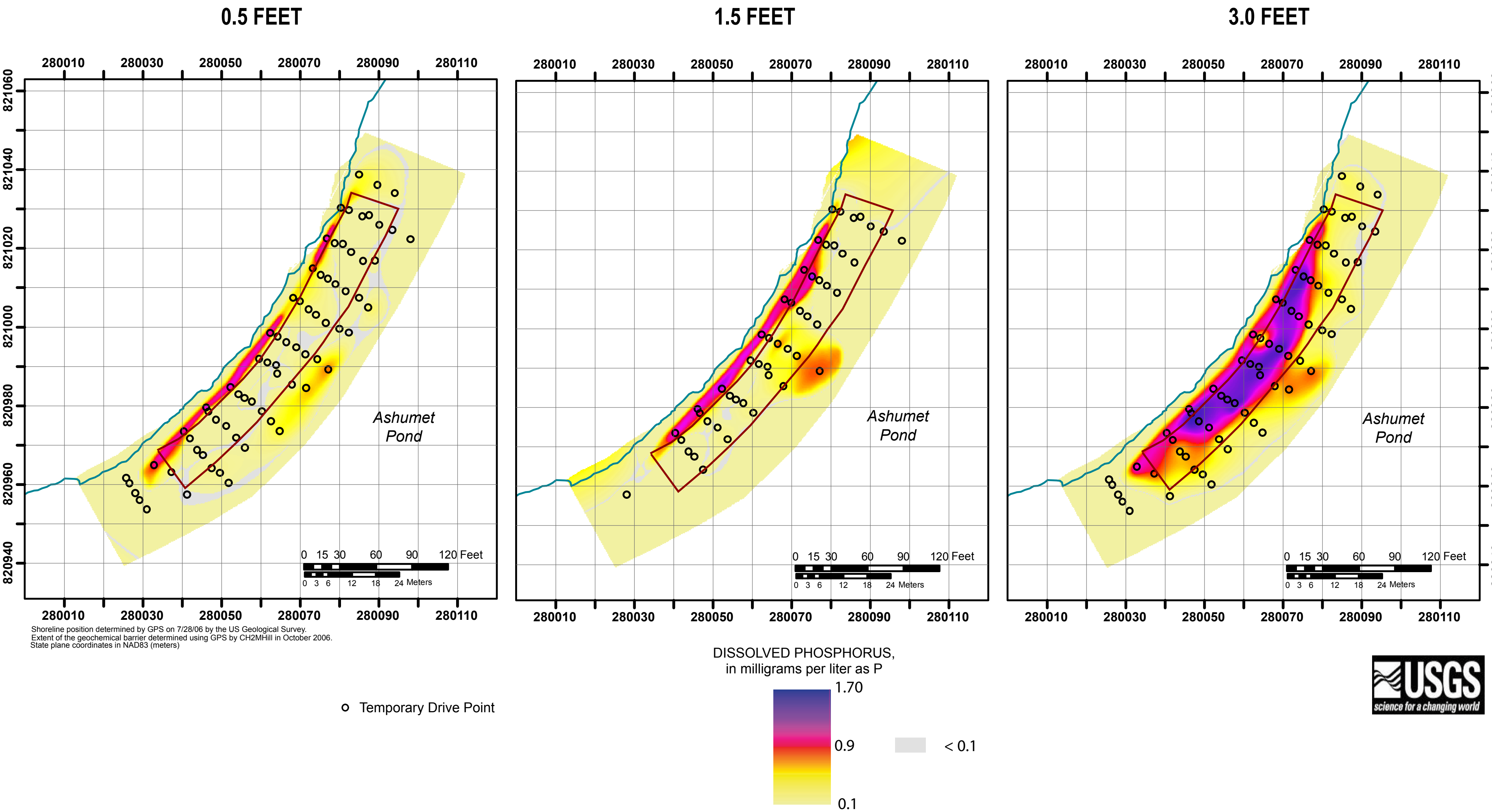


Figure 9g. Map showing distribution of dissolved phosphorus in August 2006 in pond-bottom ground water at three depths below and within the geochemical barrier at Ashumet Pond. The maps are generated from hand-contours using a geographic information system (GIS).

Table 1. Field and laboratory chemical analysis of samples from vertical pond-bottom multilevel samplers collected prior to installation, and two, eight, 11 and 23 months after barrier installation.

[Location of sites shown in figure 2. F shorthand for MA-FSW. F645P01 could not be installed during iron-barrier emplacement because of coffer dam. This sampler was temporarily driven during the sampling round. Length of sampling interval is 0.04 ft. Elevations of all permanently installed devices were determined on October 6, 2004 by the U.S. Geological Survey. pH values were determined and nitrogen samples were collected at three of the 10 profiles. Phosphorus and nitrogen samples were analyzed at the USGS National Water Quality Laboratory. State plane coordinates are from North Atlantic Datum 1983 (NAD83); µS/cm, microsiemens per centimeter at 25oC; <, actual value less than method detection limit; E, estimated value; ---, no data. Results prior to August 2006 were reported in letters dated 12/13/04, 7/21/05, and 9/26/05.]

					Date Sampled					Specific Conductance (µS/cm)					Dissolved Oxygen (mg/L)				
USGS Site Name	**Easting NAD83 (meters)**	**Northing NAD83 (meters)**	**Depth Below Pond Bottom (feet)**	**Altitude of Port (feet)**	**Pre July 2004**	**Post 1 October 2004**	**Post 2 April 2005**	**Post 3 July 2005**	**Post 5 August 2006**	**Pre July 2004**	**Post 1 October 2004**	**Post 2 April 2005**	**Post 3 July 2005**	**Post 5 August 2006**	**Pre July 2004**	**Post 1 October 2004**	**Post 2 April 2005**	**Post 3 July 2005**	**Post 5 August 2006**
F639P01-0000	280035.999	820958.504	0.02	42.84	7/20/2004	10/29/2004	---	7/18/05	8/1/2006	98.5	101	---	99.0	99.1	0.700	10.2	---	2.31	7.85
F639P01-0000.8	280035.999	820958.504	0.82	42.04	7/20/2004	10/29/2004	---	7/18/05	8/1/2006	153	233	---	179	106	---	1.32	---	0.215	0.225
F639P01-0001.6	280035.999	820958.504	1.62	41.24	7/20/2004	10/29/2004	---	7/18/05	8/1/2006	138	227	---	180	102.9	---	2.44	---	0.145	1.62
F639P01-0002.2	280035.999	820958.504	2.22	40.64	7/20/2004	10/29/2004	---	7/18/05	8/1/2006	120	221	---	181	104.8	2.10	2.86	---	0.200	1.66
F639P01-0003.4	280035.999	820958.504	3.42	39.44	7/20/2004	10/29/2004	---	7/18/05	8/1/2006	94.6	216	---	178	118.1	8.30	6.83	---	0.435	1.44
F640P01-0000	280041.672	820968.084	0.02	43.22	7/21/2004	10/29/2004	4/20/2005	7/19/05	8/1/2006	97.6	107	199	192	173.2	8.40	2.82	---	2.11	0.390
F640P01-0000.8	280041.672	820968.084	0.82	42.42	7/21/2004	10/29/2004	4/20/2005	7/19/05	8/1/2006	153	119	197	210	184	0.700	0.170	0.000	0.060	3.67
F640P01-0001.6	280041.672	820968.084	1.62	41.62	7/21/2004	10/29/2004	4/20/2005	7/19/05	8/1/2006	162	126	181	203	187.9	0.900	0.750	0.025	0.000	0.145
F640P01-0002.2	280041.672	820968.084	2.22	41.02	7/21/2004	10/29/2004	4/20/2005	7/19/05	8/1/2006	160	128	157	192	183.7	0.700	3.77	0.250	0.160	0.290
F640P01-0003.4	280041.672	820968.084	3.42	39.82	7/21/2004	10/29/2004	4/20/2005	7/19/05	8/1/2006	129	156	157	187	182.6	7.60	1.93	0.155	0.165	0.670
F641P01-0000	280054.484	820973.004	0.02	41.59	7/21/2004	10/29/2004	---	7/19/05	8/1/2006	97.3	97.0	---	95.8	98.8	8.40	---	---	6.97	7.84
F641P01-0000.8	280054.484	820973.004	0.82	40.79	7/21/2004	10/29/2004	---	7/19/05	8/1/2006	160	162	---	131	98.5	2.10	0.580	---	0.920	0.115
F641P01-0001.6	280054.484	820973.004	1.62	39.99	7/21/2004	10/29/2004	---	7/19/05	8/1/2006	162	167	---	127	104.3	0.500	0.655	---	0.060	0.005
F641P01-0002.2	280054.484	820973.004	2.22	39.39	7/21/2004	10/29/2004	---	7/19/05	8/1/2006	161	165	---	122	103.2	0.500	0.645	---	0.050	0.125
F641P01-0003.4	280054.484	820973.004	3.42	38.19	7/21/2004	10/29/2004	---	7/19/05	8/1/2006	159	144	---	133.0	95.6	0.100	0.530	---	2.31	0.380
F642P01-0000	280057.364	820984.858	0.02	43.60	7/21/2004	10/29/2004	---	7/18/05	8/1/2006	101	---	---	99.0	100.2	8.40	---	---	2.11	7.35
F642P01-0000.8	280057.364	820984.858	0.82	42.80	7/21/2004	10/29/2004	---	7/18/05	8/1/2006	148	135	---	159	274	0.700	0.385	---	0.355	0.115
F642P01-0001.6	280057.364	820984.858	1.62	42.00	7/21/2004	10/29/2004	---	7/18/05	8/1/2006	154	160	---	178	311	0.400	2.63	---	0.060	0.080
F642P01-0002.2	280057.364	820984.858	2.22	41.40	7/21/2004	10/29/2004	---	7/18/05	8/1/2006	142	140	---	178	283	0.700	0.260	---	0.065	0.035
F642P01-0003.4	280057.364	820984.858	3.42	40.20	7/21/2004	10/29/2004	---	7/18/05	8/1/2006	149	---	---	158	---	---	---	---	0.315	---
F643P01-0000	280064.002	820994.228	0.02	43.82	7/22/2004	11/1/2004	4/20/2005	7/19/05	8/1/2006	103	149	523	141	184	7.80	3.12	---	2.16	2.75
F643P01-0000.8	280064.002	820994.228	0.82	43.02	7/22/2004	11/1/2004	4/20/2005	7/19/05	8/1/2006	63.6	---	262	160	---	7.30	---	---	0.060	---
F643P01-0001.6	280064.002	820994.228	1.62	42.22	7/22/2004	11/1/2004	4/20/2005	7/19/05	8/1/2006	70.2	142	199	164	214	8.20	0.375	0.000	0.015	0.725
F643P01-0002.2	280064.002	820994.228	2.22	41.62	7/22/2004	11/1/2004	4/20/2005	7/19/05	8/1/2006	196	94.7	146	136	205	7.80	3.84	0.280	0.220	0.330
F643P01-0003.4	280064.002	820994.228	3.42	40.42	7/22/2004	11/1/2004	4/20/2005	7/19/05	8/1/2006	244	86.7	148	135	204	8.10	8.22	---	0.220	0.440
F644P01-0000	280070.882	820989.998	0.02	42.66	7/22/2004	10/29/2004	---	7/19/05	8/1/2006	121	283	---	96.1	102.3	5.50	10.51	---	7.60	7.90
F644P01-0000.8	280070.882	820989.998	0.82	41.86	7/22/2004	10/29/2004	---	7/19/05	8/1/2006	153	162	---	156	91.5	0.700	0.735	---	0.885	0.260
F644P01-0001.6	280070.882	820989.998	1.62	41.06	7/22/2004	10/29/2004	---	7/19/05	8/1/2006	154	164	---	159	89.7	2.20	0.820	---	0.205	1.81
F644P01-0002.2	280070.882	820989.998	2.22	40.46	7/22/2004	10/29/2004	---	7/19/05	8/1/2006	150	162	---	156	83.1	0.100	0.790	---	0.240	0.530
F644P01-0003.4	280070.882	820989.998	3.42	39.26	7/22/2004	10/29/2004	---	7/19/05	8/1/2006	148	154	---	156	83.8	4.90	---	---	0.960	3.38
F645P01-0000	280078.725	820993.792	0.02	40.68	7/22/2004	11/1/2004	4/20/2005	7/19/05	8/2/2006	92.3	93.2	86.9	98.0	99.0	8.30	10.53	---	8.42	7.85
F645P01-0000.8	280078.725	820993.792	0.82	39.88	7/22/2004	11/1/2004	4/20/2005	7/19/05	8/2/2006	89.1	101	83.4	143	98.1	4.60	6.03	---	0.885	0.680
F645P01-0001.6	280078.725	820993.792	1.62	39.08	7/22/2004	11/1/2004	4/20/2005	7/19/05	8/2/2006	90.3	173	87.1	143	94.5	1.90	5.28	---	0.480	0.130
F645P01-0002.2	280078.725	820993.792	2.22	38.48	7/22/2004	11/1/2004	4/20/2005	7/19/05	8/2/2006	88.3	183	89.9	147	95.7	7.30	4.63	---	0.370	1.16
F645P01-0003.4	280078.725	820993.792	3.42	37.28	7/22/2004	11/1/2004	4/20/2005	7/19/05	8/2/2006	92.0	179	91.2	138	96.4	7.60	9.45	---	0.375	0.725
F646P01-0000	280072.137	821008.498	0.02	43.52	7/22/2004	10/29/2004	---	7/20/05	8/2/2006	121	---	---	144	128	5.80	---	---	2.35	5.92
F646P01-0000.8	280072.137	821008.498	0.82	42.72	7/22/2004	10/29/2004	---	7/20/05	8/2/2006	151	242	---	180	221	0.600	1.44	---	0.010	0.660
F646P01-0001.6	280072.137	821008.498	1.62	41.92	7/22/2004	10/29/2004	---	7/20/05	8/2/2006	150	212	---	189	220	1.40	0.770	---	0.035	0.795
F646P01-0002.2	280072.137	821008.498	2.22	41.32	7/22/2004	10/29/2004	---	7/20/05	8/2/2006	147	195	---	188	221	---	1.37	---	0.125	2.55
F646P01-0003.4	280072.137	821008.498	3.42	40.12	7/22/2004	10/29/2004	---	7/20/05	8/2/2006	116	195	---	193	217	0.200	4.27	---	---	2.11
F647P01-0000	280085.138	821016.427	0.02	42.48	7/23/2004	11/1/2004	---	7/20/05	8/2/2006	71.8	92.2	---	94.9	101	6.50	10.60	---	8.36	8.29
F647P01-0000.8	280085.138	821016.427	0.82	41.68	7/23/2004	11/1/2004	---	7/20/05	8/2/2006	69.9	121	---	78.0	100.0	6.20	0.945	---	0.550	0.000
F647P01-0001.6	280085.138	821016.427	1.62	40.88	7/23/2004	11/1/2004	---	7/20/05	8/2/2006	69.8	117	---	85.0	104.0	6.20	2.10	---	0.000	0.255
F647P01-0002.2	280085.138	821016.427	2.22	40.28	7/23/2004	11/1/2004	---	7/20/05	8/2/2006	69.9	116	---	79.0	101.0	6.00	0.420	---	2.15	2.58
F647P01-0003.4	280085.138	821016.427	3.42	39.08	7/23/2004	11/1/2004	---	7/20/05	8/2/2006	69.7	148	---	71.5	94.2	6.00	5.28	---	6.47	6.49
F648P01-0000	280084.569	821029.386	0.02	43.30	7/23/2004	10/29/2004	---	7/20/05	8/2/2006	94.9	---	---	95.7	146	6.77	---	---	9.10	0.075
F648P01-0000.8	280084.569	821029.386	0.82	42.50	7/23/2004	10/29/2004	---	7/20/05	8/2/2006	100	155	---	161	137	4.40	0.890	---	0.060	1.91
F648P01-0001.6	280084.569	821029.386	1.62	41.70	7/23/2004	10/29/2004	---	7/20/05	8/2/2006	104	205	---	160	135	2.65	2.39	---	0.125	4.32
F648P01-0002.2	280084.569	821029.386	2.22	41.10	7/23/2004	10/29/2004	---	7/20/05	8/2/2006	102	247	---	157	137	2.10	1.90	---	0.240	4.87
F648P01-0003.4	280084.569	821029.386	3.42	39.90	7/23/2004	10/29/2004	---	7/20/05	8/2/2006	101	121	---	137	134	2.30	1.96	---	4.64	6.74

Table 1. Field and laboratory chemical analysis of samples from vertical pond-bottom multilevel samplers collected prior to installation, and two, eight, 11 and 23 months after barrier installation *(continued)*

	pH					Ammonia (mg/L as N)					Nitrite plus nitrate (mg/L as N)				
USGS Site Name	**Pre July 2004**	**Post 1 October 2004**	**Post 2 April 2005**	**Post 3 July 2005**	**Post 5 August 2006**	**Pre July 2004**	**Post 1 October 2004**	**Post 2 April 2005**	**Post 3 July 2005**	**Post 5 August 2006**	**Pre July 2004**	**Post 1 October 2004**	**Post 2 April 2005**	**Post 3 July 2005**	**Post 5 August 2006**
F639P01-0000	---	---	---	---	---	<0.04	---	---	---	---	<0.06	---	---	---	---
F639P01-0000.8	---	---	---	---	---	<0.04	---	---	---	---	2.45	---	---	---	---
F639P01-0001.6	5.91	---	---	---	---	---	---	---	---	---	---	---	---	---	---
F639P01-0002.2	5.98	---	---	---	---	---	---	---	---	---	---	---	---	---	---
F639P01-0003.4	6.94	---	---	---	---	<0.04	---	---	---	---	3.22	---	---	---	---
F640P01-0000	7.23	---	---	---	---	---	---	---	---	---	---	---	---	---	---
F640P01-0000.8	6.48	---	---	---	---	E0.04	---	---	---	---	0.14	---	---	---	---
F640P01-0001.6	6.49	---	---	---	---	---	---	---	---	---	---	---	---	---	---
F640P01-0002.2	6.58	---	---	---	---	---	---	---	---	---	---	---	---	---	---
F640P01-0003.4	6.64	---	---	---	---	0.41	---	---	---	---	<0.06	---	---	---	---
F641P01-0000	7.29	---	---	---	---	---	---	---	---	---	---	---	---	---	---
F641P01-0000.8	6.66	---	---	---	---	0.79	---	---	---	---	<0.06	---	---	---	---
F641P01-0001.6	6.94	---	---	---	---	---	---	---	---	---	---	---	---	---	---
F641P01-0002.2	6.63	---	---	---	---	---	---	---	---	---	---	---	---	---	---
F641P01-0003.4	6.86	---	---	---	---	0.86	---	---	---	---	<0.06	---	---	---	---
F642P01-0000	7.23	---	---	---	---	<0.04	---	---	---	---	<0.06	---	---	---	---
F642P01-0000.8	6.61	---	---	---	---	0.04	---	---	---	---	<0.06	---	---	---	---
F642P01-0001.6	6.66	---	---	---	---	E0.04	---	---	---	---	<0.06	---	---	---	---
F642P01-0002.2	6.61	---	---	---	---	0.04	---	---	---	---	<0.06	---	---	---	---
F642P01-0003.4	6.65	---	---	---	---	0.04	---	---	---	---	<0.06	---	---	---	---
F643P01-0000	6.43	6.90	6.92	7.02	5.74	---	0.05	<0.04	E0.028	0.57	---	<0.06	<0.06	<0.06	<0.06
F643P01-0000.8	6.02	---	6.75	7.15	---	<0.04	---	0.079	<0.04	---	<0.06	---	<0.06	<0.06	---
F643P01-0001.6	6.36	6.95	7.10	7.13	5.00	---	<0.04	0.029	E0.039	0.77	---	<0.06	<0.06	<0.06	<0.06
F643P01-0002.2	6.27	5.81	6.46	6.60	5.45	---	<0.04	<0.04	0.079	0.79	---	<0.06	<0.06	<0.06	<0.06
F643P01-0003.4	6.4	5.79	6.32	6.56	---	<0.04	<0.04	<0.04	0.145	0.82	0.33	<0.06	<0.06	<0.06	<0.06
F644P01-0000	7.02	---	---	---	---	---	---	---	---	---	---	---	---	---	---
F644P01-0000.8	6.5	---	---	---	---	1.25	---	---	---	---	<0.06	---	---	---	---
F644P01-0001.6	6.81	---	---	---	---	---	---	---	---	---	---	---	---	---	---
F644P01-0002.2	6.83	---	---	---	---	---	---	---	---	---	---	---	---	---	---
F644P01-0003.4	6.65	---	---	---	---	1.23	---	---	---	---	<0.06	---	---	---	---
F645P01-0000	7.19	5.95	6.32	6.95	---	<0.04	<0.04	<0.04	---	E0.009	0.68	0.05	0.93	---	<0.06
F645P01-0000.8	6.66	6.20	5.67	6.25	---	<0.04	<0.04	<0.04	<0.04	1.21	0.81	0.80	0.96	1.66	1.99
F645P01-0001.6	6.48	6.36	6.32	6.20	---	<0.04	<0.04	<0.04	<0.04	1.51	0.82	0.85	0.90	1.90	2.13
F645P01-0002.2	6.64	6.35	6.00	6.15	---	<0.04	<0.04	<0.04	<0.04	1.45	0.83	<0.06	0.98	1.84	1.97
F645P01-0003.4	6.98	6.32	6.64	6.12	---	<0.04	<0.04	<0.04	<0.04	1.59	0.17	0.69	0.92	1.80	2.12
F646P01-0000	6.42	---	---	---	---	---	---	---	---	---	---	---	---	---	---
F646P01-0000.8	6.17	---	---	---	---	E0.03	---	---	---	---	<0.06	---	---	---	---
F646P01-0001.6	6.34	---	---	---	---	---	---	---	---	---	---	---	---	---	---
F646P01-0002.2	6.43	---	---	---	---	---	---	---	---	---	---	---	---	---	---
F646P01-0003.4	6.25	---	---	---	---	0.43	---	---	---	---	<0.06	---	---	---	---
F647P01-0000	6.53	7.14	---	6.99	---	<0.04	<0.04	---	<0.04	E0.007	0.47	<0.06	---	<0.06	<0.06
F647P01-0000.8	6.43	6.92	---	7.00	---	<0.04	<0.04	---	<0.04	0.01	0.48	<0.06	---	<0.06	<0.06
F647P01-0001.6	6.57	7.07	---	7.07	---	<0.04	<0.04	---	E0.020	0.02	0.47	<0.06	---	<0.06	E0.04
F647P01-0002.2	6.23	7.00	---	6.56	---	<0.04	<0.04	---	<0.04	<0.01	0.47	0.04	---	0.30	0.36
F647P01-0003.4	6.45	4.86	---	5.72	---	<0.04	<0.04	---	<0.04	<0.01	0.47	0.30	---	0.60	0.71
F648P01-0000	6.21	---	---	---	---	---	---	---	---	---	---	---	---	---	---
F648P01-0000.8	6.01	---	---	---	---	<0.04	---	---	---	---	0.45	---	---	---	---
F648P01-0001.6	6.11	---	---	---	---	---	---	---	---	---	---	---	---	---	---
F648P01-0002.2	6.15	---	---	---	---	---	---	---	---	---	---	---	---	---	---
F648P01-0003.4	6.24	---	---	---	---	<0.04	---	---	---	---	0.35	---	---	---	---

Table 1. Field and laboratory chemical analysis of samples from vertical pond-bottom multilevel samplers collected prior to installation, and two, eight, 11 and 23 months after barrier installation (*continued*).

	Nitrite (mg/L as N)					Phosphorus (mg/L as P)				
USGS Site Name	Pre July 2004	Post 1 October 2004	Post 2 April 2005	Post 3 July 2005	Post 5 August 2006	Pre July 2004	Post 1 October 2004	Post 2 April 2005	Post 3 July 2005	Post 5 August 2006
F639P01-0000	<0.008	---	---	---	---	0.05	0.03	---	0.04	<0.02
F639P01-0000.8	<0.008	---	---	---	---	<0.01	0.65	---	0.73	1.10
F639P01-0001.6	---	---	---	---	---	<0.01	0.74	---	0.79	1.09
F639P01-0002.2	---	---	---	---	---	<0.01	0.73	---	0.76	1.08
F639P01-0003.4	<0.008	---	---	---	---	<0.01	0.80	---	0.81	1.11
F640P01-0000	---	---	---	---	---	0.20	0.02	0.08	0.11	0.09
F640P01-0000.8	E0.005	---	---	---	---	1.67	0.08	0.46	0.17	0.15
F640P01-0001.6	---	---	---	---	---	1.20	0.07	0.77	0.89	0.31
F640P01-0002.2	---	---	---	---	---	1.15	0.96	1.51	1.06	0.68
F640P01-0003.4	<0.008	---	---	---	---	1.06	1.42	1.51	1.03	0.75
F641P01-0000	---	---	---	---	---	0.06	<0.02	---	E0.02	<0.02
F641P01-0000.8	<0.008	---	---	---	---	1.20	1.23	---	0.16	<0.02
F641P01-0001.6	---	---	---	---	---	1.04	1.03	---	0.20	0.04
F641P01-0002.2	---	---	---	---	---	1.00	0.36	---	0.28	0.08
F641P01-0003.4	<0.008	---	---	---	---	1.12	1.21	---	0.86	0.43
F642P01-0000	<0.008	---	---	---	---	0.33	---	---	0.03	<0.02
F642P01-0000.8	<0.008	---	---	---	---	1.46	0.04	---	1.50	0.97
F642P01-0001.6	<0.008	---	---	---	---	1.45	<0.02	---	0.06	<0.02
F642P01-0002.2	<0.008	---	---	---	---	1.45	<0.02	---	0.05	<0.02
F642P01-0003.4	<0.008	---	---	---	---	1.38	---	---	1.20	---
F643P01-0000	---	<0.008	<0.008	<0.008	<0.002	0.14	<0.02	0.55	0.10	0.16
F643P01-0000.8	<0.008	---	<0.008	<0.008	---	0.26	---	<0.02	0.03	---
F643P01-0001.6	---	<0.008	<0.008	<0.008	<0.002	0.28	0.04	0.36	0.16	0.18
F643P01-0002.2	---	<0.008	<0.008	<0.008	<0.002	0.52	0.22	2.66	1.68	1.41
F643P01-0003.4	<0.008	<0.008	<0.008	<0.008	<0.002	1.05	0.35	2.84	1.84	1.46
F644P01-0000	---	---	---	---	---	0.49	0.03	---	0.02	<0.02
F644P01-0000.8	<0.008	---	---	---	---	1.71	0.15	---	0.19	0.09
F644P01-0001.6	---	---	---	---	---	1.70	0.85	---	0.26	0.14
F644P01-0002.2	---	---	---	---	---	1.61	1.33	---	0.45	0.37
F644P01-0003.4	<0.008	---	---	---	---	1.71	2.03	---	1.07	0.58
F645P01-0000	<0.008	<0.008	<0.008	---	<0.002	0.59	0.02	0.35	0.02	<0.02
F645P01-0000.8	<0.008	<0.008	<0.008	0.043	<0.002	0.69	0.36	0.41	0.44	0.46
F645P01-0001.6	<0.008	<0.008	<0.008	0.043	<0.002	0.70	0.43	0.36	0.42	0.63
F645P01-0002.2	<0.008	<0.008	<0.008	0.031	<0.002	0.63	0.42	0.40	0.50	0.59
F645P01-0003.4	<0.008	<0.008	<0.008	0.025	<0.002	0.15	0.40	0.31	0.46	0.64
F646P01-0000	---	---	---	---	---	0.77	---	---	0.23	0.10
F646P01-0000.8	<0.008	---	---	---	---	1.37	0.04	---	0.61	0.34
F646P01-0001.6	---	---	---	---	---	1.40	0.10	---	2.79	1.48
F646P01-0002.2	---	---	---	---	---	1.05	0.24	---	3.08	1.46
F646P01-0003.4	<0.008	---	---	---	---	1.45	0.92	---	2.65	1.37
F647P01-0000	<0.008	<0.008	---	<0.008	<0.002	0.73	<0.02	---	E0.01	<0.02
F647P01-0000.8	<0.008	<0.008	---	0.011	E0.0013	0.72	0.10	---	0.05	E0.015
F647P01-0001.6	<0.008	<0.008	---	0.016	0.003	0.71	0.09	---	0.03	<0.02
F647P01-0002.2	<0.008	<0.008	---	E0.004	0.007	0.71	0.03	---	<0.02	<0.02
F647P01-0003.4	<0.008	<0.008	---	<0.008	<0.002	0.73	0.63	---	0.55	0.41
F648P01-0000	---	---	---	---	---	0.51	---	---	E0.02	0.03
F648P01-0000.8	<0.008	---	---	---	---	0.70	<0.02	---	0.04	<0.02
F648P01-0001.6	---	---	---	---	---	0.83	<0.02	---	0.04	0.16
F648P01-0002.2	---	---	---	---	---	0.92	<0.02	---	0.05	0.08
F648P01-0003.4	<0.008	---	---	---	---	0.94	0.30	---	0.09	0.33

Table 2. Field chemical analysis of samples collected from vertical diffusion samplers collected 2, 11, and 23 months after barrier installation.

[Location of sites shown in figure 2. DC shorthand for diffusion chamber. Elevations of all permanently installed devices were determined on October 6, 2004 by the U.S. Geological Survey. Field phosphate was determined onsite using a colorimetric method. mS/cm, microsiemens per centimeter at 25oC; ---, none data]

				October 2004			July 2005			August 2006		
USGS Site Name	Pond-Bottom Altitude	Mid-Port Depth Below Pond Bottom (feet)	Altitude of Port (feet)	Colored Film on Bottles	Specific Conductance (µS/cm)	Field Phosphate (mg/L as P)	Colored Film on Bottles	Specific Conductance (µS/cm)	Field Phosphate (mg/L as P)	Colored Film on Bottles	Specific Conductance (µS/cm)	Field Phosphate (mg/L as P)
DC1-01	42.67	-0.05	42.72	reddish brown	96.7	0.00	none	186	0.82	none	136	1.24
DC1-02	42.67	0.12	42.55	reddish brown	183	0.44	none	181	0.82	none	122	1.24
DC1-03	42.67	0.29	42.38	reddish brown	108	0.23	none	183	0.80	none	130	1.14
DC1-04	42.67	0.46	42.21	reddish brown	63.8	0.08	none	181	0.73	none	126	1.21
DC1-05	42.67	0.63	42.04	reddish brown	177	0.46	none	187	0.73	none	132	1.06
DC1-06	42.67	0.80	41.87	reddish brown	176	0.42	none	187	0.78	none	127	1.17
DC1-07	42.67	0.97	41.70	reddish brown	219	0.42	none	179	0.75	none	138	1.04
DC1-08	42.67	1.14	41.53	reddish brown	189	0.38	none	180	0.83	none	136	1.37
DC1-09	42.67	1.31	41.36	reddish brown	191	0.42	none	185	0.91	none	126	1.61
DC1-10	42.67	1.64	41.03	reddish brown	194	0.47	none	191	0.80	none	139	1.35
DC1-11	42.67	1.97	40.70	none	201	0.47	none	186	0.82	none	128	1.32
DC1-12	42.67	2.30	40.37	none	202	0.69	none	185	0.80	none	141	1.52
DC1-13	42.67	2.63	40.04	none	202	0.59	none	187	0.72	none	138	1.30
DC2-01	43.22	0.16	43.06	reddish brown	104	0.10	reddish brown	198	0.08	reddish brown	173	0.47
DC2-02	43.22	0.33	42.89	reddish brown	99.5	0.00	reddish brown	188	0.00	reddish brown	174	0.39
DC2-03	43.22	0.50	42.72	reddish brown	92.8	0.07	reddish brown	183	0.02	reddish brown	173	0.41
DC2-04	43.22	0.67	42.55	reddish brown	106	0.00	reddish brown	182	0.00	reddish brown	153	0.24
DC2-05	43.22	0.84	42.38	reddish brown	97.7	0.00	reddish brown	180	0.00	reddish brown	162	0.24
DC2-06	43.22	1.01	42.21	reddish brown	96.3	0.00	reddish brown	184	0.00	reddish brown	155	0.08
DC2-07	43.22	1.18	42.04	reddish brown	95.0	0.03	reddish brown	196	0.11	reddish brown	168	0.26
DC2-08	43.22	1.35	41.87	reddish brown	96.1	0.02	reddish brown	202	0.18	reddish brown	189	0.08
DC2-09	43.22	1.52	41.70	reddish brown	85.4	0.00	reddish brown	186	0.20	reddish brown	178	0.05
DC2-10	43.22	1.85	41.37	reddish brown	96.8	0.59	reddish brown	183	0.29	reddish brown	190	0.42
DC2-11	43.22	2.18	41.04	none	109	0.49	none	193	0.96	none	165	0.75
DC2-12	43.22	2.51	40.71	none	109	0.52	none	185	1.04	none	180	1.03
DC2-13	43.22	2.84	40.38	none	102	0.60	none	182	1.09	none	177	1.11
DC3-01	43.22	0.10	43.12	reddish brown	153	0.05	reddish brown	138	0.10	gray	192	0.08
DC3-02	43.22	0.27	42.95	reddish brown	158	0.00	reddish brown	114	0.10	gray	197	0.00
DC3-03	43.22	0.44	42.78	reddish brown	142	0.00	reddish brown	122	0.00	reddish brown	193	0.00
DC3-04	43.22	0.61	42.61	reddish brown	134	0.00	reddish brown	89.4	0.03	reddish brown	194	0.00
DC3-05	43.22	0.78	42.44	reddish brown	138	0.00	reddish brown	128	0.02	reddish brown	192	0.00
DC3-06	43.22	0.95	42.27	reddish brown	152	0.00	reddish brown	134	0.03	reddish brown	190	0.00
DC3-07	43.22	1.12	42.10	reddish brown	138	0.02	reddish brown	154	0.11	gray	192	0.02
DC3-08	43.22	1.29	41.93	reddish brown	124	0.02	reddish brown	158	0.15	gray	193	0.00
DC3-09	43.22	1.46	41.76	reddish brown	123	0.11	reddish brown	160	0.10	gray	189	0.00
DC3-10	43.22	1.79	41.43	reddish brown	116	0.00	reddish brown	170	0.18	gray	191	0.00
DC3-11	43.22	2.12	41.10	none	112	0.03	reddish brown	168	0.67	gray	197	0.00
DC3-12	43.22	2.45	40.77	none	96.5	0.62	reddish brown	154	1.37	none	189	1.24
DC3-13	43.22	2.78	40.44	none	105	1.29	none	156	1.63	none	192	1.58
DC4-01	43.78	0.31	43.47	reddish brown	111	0.13	reddish brown	132	0.07	none	204	0.55
DC4-02	43.78	0.48	43.30	reddish brown	102	0.08	reddish brown	124	0.03	reddish brown	200	0.08
DC4-03	43.78	0.65	43.13	reddish brown	115	0.08	reddish brown	122	0.03	reddish brown	205	0.10
DC4-04	43.78	0.82	42.96	reddish brown	91.8	0.03	reddish brown	118	0.03	reddish brown	203	0.00
DC4-05	43.78	0.99	42.79	reddish brown	107	0.13	reddish brown	115	0.00	reddish brown	204	0.00
DC4-06	43.78	1.16	42.62	reddish brown	125	0.05	reddish brown	120	0.03	gray	204	0.00

USGS Site Name	Pond-Bottom Altitude	Mid-Port Depth Below Pond Bottom (feet)	Altitude of Port (feet)	October 2004 Colored Film on Bottles	October 2004 Specific Conductance (µS/cm)	October 2004 Field Phosphate (mg/L as P)	July 2005 Colored Film on Bottles	July 2005 Specific Conductance (µS/cm)	July 2005 Field Phosphate (mg/L as P)	August 2006 Colored Film on Bottles	August 2006 Specific Conductance (µS/cm)	August 2006 Field Phosphate (mg/L as P)
DC4-07	43.78	1.33	42.45	reddish brown	128	0.02	reddish brown	124	0.00	gray	210	0.00
DC4-08	43.78	1.50	42.28	reddish brown	141	0.08	reddish brown	133	0.00	gray	204	0.00
DC4-09	43.78	1.67	42.11	reddish brown	159	0.11	reddish brown	129	0.00	gray	203	0.00
DC4-10	43.78	2.00	41.78	reddish brown	136	0.03	reddish brown	136	0.02	gray	211	0.00
DC4-11	43.78	2.33	41.45	reddish brown	98.4	0.00	reddish brown	127	0.91	none	196	0.95
DC4-12	43.78	2.66	41.12	none	104	0.15	reddish brown	121	1.34	none	196	1.06
DC4-13	43.78	2.99	40.79	none	103	0.28	none	133	1.73	none	190	1.30
DC5-01	42.69	-0.02	42.71	reddish brown	240	0.02	reddish brown	202	0.34	reddish brown	127	0.44
DC5-02	42.69	0.15	42.54	reddish brown	220	0.00	reddish brown	198	0.16	gray	130	0.44
DC5-03	42.69	0.32	42.37	reddish brown	225	0.00	reddish brown	199	0.13	gray	133	0.26
DC5-04	42.69	0.49	42.20	reddish brown	227	0.00	reddish brown	199	0.11	gray	135	0.38
DC5-05	42.69	0.66	42.03	reddish brown	221	0.03	reddish brown	194	0.05	gray	129	0.44
DC5-06	42.69	0.83	41.86	reddish brown	221	0.03	reddish brown	195	0.23	gray	129	0.42
DC5-07	42.69	1.00	41.69	reddish brown	216	0.00	reddish brown	193	0.11	gray	128	0.39
DC5-08	42.69	1.17	41.52	reddish brown	234	0.16	reddish brown	197	0.15	gray	130	0.33
DC5-09	42.69	1.34	41.35	reddish brown	228	0.86	reddish brown	196	0.15	gray	128	0.41
DC5-10	42.69	1.67	41.02	reddish brown	221	0.52	reddish brown	200	0.15	gray	130	0.64
DC5-11	42.69	2.00	40.69	reddish brown	203	0.86	reddish brown	195	0.07	reddish brown	131	0.52
DC5-12	42.69	2.33	40.36	none	157	0.85	none	193	1.35	reddish brown	132	1.39
DC5-13	42.69	2.66	40.03	none	151	1.37	none	188	1.29	none	121	1.42
DC6-01	42.22	-0.18	42.40	reddish brown	101	0.02	reddish brown	101	0.00	gray	---	0.00
DC6-02	42.22	-0.01	42.23	reddish brown	122	0.00	reddish brown	122	0.00	reddish brown	100	0.02
DC6-03	42.22	0.16	42.06	reddish brown	154	0.10	reddish brown	154	0.11	reddish brown	86.6	0.02
DC6-04	42.22	0.33	41.89	reddish brown	161	0.07	reddish brown	161	0.13	reddish brown	84.9	0.13
DC6-05	42.22	0.50	41.72	reddish brown	164	0.13	reddish brown	164	0.16	reddish brown	86.4	0.07
DC6-06	42.22	0.67	41.55	reddish brown	163	0.15	reddish brown	142	0.15	gray	98.7	0.03
DC6-07	42.22	0.84	41.38	reddish brown	153	0.08	reddish brown	138	0.03	gray	80.3	0.02
DC6-08	42.22	1.01	41.21	reddish brown	147	0.05	reddish brown	142	0.07	gray	92.9	0.05
DC6-09	42.22	1.18	41.04	reddish brown	156	0.18	reddish brown	144	0.08	gray	86.6	0.07
DC6-10	42.22	1.51	40.71	reddish brown	145	0.05	reddish brown	143	0.18	gray	83.6	0.10
DC6-11	42.22	1.84	40.38	reddish brown	141	0.83	reddish brown	140	0.33	gray	83.4	0.72
DC6-12	42.22	2.17	40.05	none	143	1.08	reddish brown	146	1.22	none	87.9	0.70
DC6-13	42.22	2.50	39.72	none	148	1.26	none	146	1.03	none	132	0.73
DC7-01	43.72	-0.26	43.98	reddish brown	---	---	reddish brown	98	0.05	reddish brown	105	0.08
DC7-02	43.72	-0.09	43.81	reddish brown	---	---	reddish brown	98	0.03	reddish brown	153	0.10
DC7-03	43.72	0.08	43.64	reddish brown	83	0.00	reddish brown	186	0.03	reddish brown	189	0.51
DC7-04	43.72	0.25	43.47	reddish brown	81	0.00	reddish brown	189	0.00	reddish brown	193	0.54
DC7-05	43.72	0.42	43.30	reddish brown	87	0.00	reddish brown	194	0.00	reddish brown	188	0.33
DC7-06	43.72	0.59	43.13	reddish brown	87.6	0.00	reddish brown	199	0.00	gray	183	0.18
DC7-07	43.72	0.76	42.96	reddish brown	91.3	0.00	reddish brown	197	0.00	gray	190	0.21
DC7-08	43.72	0.93	42.79	reddish brown	93.5	0.00	reddish brown	200	0.00	gray	187	0.21
DC7-09	43.72	1.10	42.62	reddish brown	94.7	0.00	reddish brown	199	0.00	gray	194	0.39
DC7-10	43.72	1.43	42.29	reddish brown	103	0.00	reddish brown	200	0.08	gray	204	0.33
DC7-11	43.72	1.76	41.96	reddish brown	102	0.00	reddish brown	201	0.00	none	171	1.13
DC7-12	43.72	2.09	41.63	reddish brown	95.7	0.00	none	198	1.13	none	186	0.54
DC7-13	43.72	2.42	41.30	reddish brown	82.4	0.00	none	225	0.91	none	244	1.03
DC8-01	43.46	-0.02	43.48	reddish brown	102	0.00	reddish brown	109	0.00	reddish brown	132	0.03
DC8-02	43.46	0.15	43.31	reddish brown	150	0.00	reddish brown	138	0.13	reddish brown	138	0.05

USGS Site Name	Pond-Bottom Altitude	Mid-Port Depth Below Pond Bottom (feet)	Altitude of Port (feet)	October 2004			July 2005			August 2006		
				Colored Film on Bottles	Specific Conductance (µS/cm)	Field Phosphate (mg/L as P)	Colored Film on Bottles	Specific Conductance (µS/cm)	Field Phosphate (mg/L as P)	Colored Film on Bottles	Specific Conductance (µS/cm)	Field Phosphate (mg/L as P)
DC8-03	43.46	0.32	43.14	reddish brown	150	0.00	reddish brown	140	0.00	reddish brown	154	0.05
DC8-04	43.46	0.49	42.97	reddish brown	132	0.00	reddish brown	142	0.00	reddish brown	149	0.07
DC8-05	43.46	0.66	42.80	reddish brown	132	0.00	reddish brown	134	0.00	reddish brown	139	0.00
DC8-06	43.46	0.83	42.63	reddish brown	146	0.00	reddish brown	137	0.03	reddish brown	---	0.00
DC8-07	43.46	1.00	42.46	reddish brown	124	0.00	reddish brown	129	0.05	reddish brown	154	0.05
DC8-08	43.46	1.17	42.29	reddish brown	175	0.00	reddish brown	128	0.07	reddish brown	145	0.07
DC8-09	43.46	1.34	42.12	reddish brown	166	0.00	reddish brown	131	0.07	reddish brown	145	0.31
DC8-10	43.46	1.67	41.79	reddish brown	187	0.00	reddish brown	132	0.03	reddish brown	142	0.20
DC8-11	43.46	2.00	41.46	reddish brown	167	0.00	reddish brown	125	0.05	reddish brown	126	0.24
DC8-12	43.46	2.33	41.13	none	153	0.00	reddish brown	117	0.02	reddish brown	128	0.23
DC8-13	43.46	2.66	40.80	none	193	0.00	reddish brown	132	0.23	reddish brown	193	0.23

Table 3. Location data and field chemical analysis of samples collected from four horizontal multiport samplers installed at 0.5 and 3.0 feet below the pond bottom along two transects in the geochemical barrier.

[Location of sites shown in figure 2. Dissolved oxygen and field phosphate were determined onsite using a colorimetric method. mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25°C; ---, no analysis]

				October 28, 2004				July 21, 2005				November 10, 2005				August 8, 2006			
Line Number	Line Description	Depth Below Pond Bottom (feet)	Distance from Mean Shore (feet)	Specific Conductance (µS/cm)	Oxygen, dissolved (mg/L)	pH (standard units)	Field Phosphate, dissolved (mg/L as P)	Specific Conductance (µS/cm)	Oxygen, dissolved (mg/L)	pH (standard units)	Field Phosphate, dissolved (mg/L as P)	Specific Conductance (µS/cm)	Oxygen, dissolved (mg/L)	pH (standard units)	Field Phosphate, dissolved (mg/L as P)	Specific Conductance (µS/cm)	Oxygen, dissolved (mg/L)	pH (standard units)	Field Phosphate, dissolved (mg/L as P)
1	South	0.5	-1.1	29.0	7.60	10.960	0.00	258	0.00	6.93	0.18	104	0.00	---	0.10	249	0.02	6.80	0.02
1	South	0.5	1.8	69.7	7.75	10.190	0.00	235	0.00	6.94	0.03	166	0.00	---	0.10	191	0.00	7.06	0.02
1	South	0.5	4.7	---	---	---	---	157	0.00	6.86	0.05	166	0.00	---	0.00	148	0.00	7.05	0.03
1	South	0.5	7.6	142	7.73	9.500	0.00	122	1.70	7.08	0.03	137	3.77	---	0.00	119	3.54	6.73	0.00
1	South	0.5	10.5	119	7.98	4.580	0.00	115	1.88	7.31	0.10	143	3.68	---	0.00	167	0.16	6.75	0.03
1	South	0.5	13.4	114	8.39	2.950	0.00	113	2.22	8.18	0.03	178	0.80	---	0.00	163	0.19	7.09	0.02
1	South	0.5	16.3	110	8.21	0.050	0.00	120	1.70	7.72	0.11	209	0.01	---	0.02	177	0.00	7.41	0.15
1	South	0.5	19.2	214	7.60	0.040	0.00	134	0.00	7.99	0.13	170	0.02	---	0.00	133	0.06	7.60	0.20
1	South	0.5	22.1	245	7.39	0.010	0.05	163	0.00	8.34	0.11	165	0.00	---	0.02	153	0.02	7.70	0.36
1	South	0.5	25.0	238	7.71	0.010	0.02	152	0.00	8.31	0.18	159	0.02	---	0.07	163	0.00	7.63	0.29
1	South	0.5	27.9	231	7.41	0.005	0.02	156	0.00	8.53	0.28	176	0.00	---	0.10	172	0.00	7.58	0.28
1	South	0.5	30.8	186	8.21	0.115	0.00	117	0.01	8.75	0.23	178	0.06	---	0.08	127	0.07	7.91	0.28
1	South	0.5	33.7	176	7.65	0.065	0.00	115	0.02	8.14	0.33	202	0.01	---	0.13	107	0.00	7.59	0.28
1	South	0.5	36.6	168	7.68	0.035	0.10	132	0.00	7.97	0.16	192	0.01	---	0.08	103	0.00	7.27	0.05
1	South	0.5	39.5	171	7.23	2.590	0.05	130	0.56	7.55	0.07	149	0.24	---	0.03	106	0.23	7.16	0.03
1	South	3.0	-1.1	110	6.19	0.010	0.03	181	0.04	6.08	1.03	64.1	8.43	---	0.10	206	0.20	5.98	1.50
1	South	3.0	1.8	98.8	5.23	0.000	0.03	192	0.10	6.32	0.86	133	4.52	---	0.70	177	0.14	6.03	1.44
1	South	3.0	4.7	63.1	5.34	0.105	0.03	172	0.03	6.32	1.40	171	0.03	---	0.96	189	0.12	5.98	1.34
1	South	3.0	7.6	99.9	5.81	0.115	0.02	164	0.05	6.51	1.11	185	0.07	---	1.04	216	0.06	6.00	1.17
1	South	3.0	10.5	131	6.91	0.710	0.05	159	0.06	6.83	1.13	250	0.01	---	0.31	252	0.09	6.14	1.16
1	South	3.0	13.4	104	6.68	0.255	0.05	164	0.01	7.05	0.73	247	0.00	---	0.23	272	0.02	6.52	0.91
1	South	3.0	16.3	86.1	6.91	0.685	0.00	171	0.04	7.11	1.14	260	0.02	---	0.64	220	0.01	6.86	0.91
1	South	3.0	19.2	165	6.89	0.015	0.03	189	0.00	7.25	1.27	247	0.04	---	0.95	181	0.07	7.14	1.32
1	South	3.0	22.1	234	6.95	0.015	0.36	211	0.00	7.53	0.72	174	0.02	---	0.15	164	0.05	7.61	0.46
1	South	3.0	25.0	238	7.12	0.005	0.88	200	0.00	7.62	0.39	159	0.02	---	0.02	169	0.07	7.55	0.33
1	South	3.0	27.9	230	7.17	0.025	0.36	186	0.00	7.88	0.24	176	0.02	---	0.05	179	0.00	7.48	0.21
1	South	3.0	30.8	225	7.34	0.005	0.47	154	0.00	8.00	0.24	182	0.02	---	0.05	149	0.00	7.35	0.18
1	South	3.0	33.7	196	7.31	0.020	0.29	136	0.00	7.67	0.24	211	0.01	---	0.20	117	0.01	7.16	0.23
1	South	3.0	36.6	171	6.97	0.015	0.96	133	0.00	6.92	0.38	194	0.03	---	0.54	96.1	0.23	6.58	0.13
1	South	3.0	39.5	155	6.55	0.070	1.04	129	0.01	6.16	0.70	165	0.05	---	0.67	85.1	0.74	5.85	0.39
2	North	0.5	-1.1	168	7.24	0.010	0.00	170	0.00	7.53	0.57	518	0.02	---	0.02	202	0.02	6.75	0.38
2	North	0.5	1.8	140	7.17	0.130	0.00	173	0.00	7.00	0.24	283	0.01	---	0.05	159	0.04	6.92	0.08
2	North	0.5	4.7	191	7.61	0.250	0.00	181	0.03	7.00	0.03	167	0.01	---	0.00	185	0.01	7.21	0.15
2	North	0.5	7.6	198	7.55	0.020	0.02	207	0.00	7.00	0.03	198	0.01	---	0.03	199	0.00	7.21	0.10
2	North	0.5	10.5	162	7.71	0.000	0.00	200	0.01	7.05	0.10	216	0.00	---	0.03	219	0.05	7.24	0.11
2	North	0.5	13.4	170	7.76	0.060	0.00	164	0.00	6.61	0.07	221	0.00	---	0.07	177	0.00	7.07	0.16
2	North	0.5	16.3	149	7.82	0.010	0.00	156	0.00	6.74	0.05	226	0.00	---	0.07	128	0.00	7.14	0.11
2	North	0.5	19.2	183	7.87	0.000	0.03	186	0.00	6.32	0.05	226	0.01	---	0.05	144	0.00	6.83	0.15
2	North	0.5	22.1	212	8.23	0.000	0.00	172	0.00	7.18	0.07	189	0.02	---	0.03	124	0.00	7.11	0.07
2	North	0.5	25.0	211	8.20	0.020	0.07	153	0.00	6.75	0.13	200	0.01	---	0.03	145	0.00	6.89	0.07
2	North	0.5	27.9	188	7.86	0.140	0.00	146	0.00	6.88	0.07	196	0.01	---	0.02	128	0.01	6.91	0.15
2	North	0.5	30.8	113	7.47	1.530	0.00	169	0.00	6.27	0.13	242	0.36	---	0.00	225	1.50	6.23	1.04
2	North	0.5	33.7	110	7.39	0.715	0.00	84.8	0.00	7.05	0.07	131	0.06	---	0.00	102	0.04	6.81	0.16
2	North	0.5	36.6	123	6.97	0.350	0.00	94.5	0.48	6.49	0.07	175	0.73	---	0.00	137	2.20	6.45	0.08
2	North	0.5	39.5	113	6.54	0.370	0.00	88.5	1.11	6.24	0.02	104	1.92	---	0.00	101	2.55	6.03	0.08
2	North	3.0	-1.1	108	6.29	0.020	0.00	161	0.06	6.76	1.68	560	0.07	---	0.41	192	0.05	6.52	1.71
2	North	3.0	1.8	131	6.69	0.000	0.02	202	0.02	7.44	1.04	403	0.01	---	0.41	206	0.04	6.89	0.80
2	North	3.0	4.7	253	7.10	0.005	0.05	227	0.01	7.75	0.03	180	0.01	---	0.08	218	0.00	7.25	0.90
2	North	3.0	7.6	226	7.03	0.035	0.10	234	0.02	7.16	0.21	212	0.04	---	0.23	248	0.00	7.03	1.06
2	North	3.0	10.5	192	7.20	0.000	0.05	206	0.04	7.62	0.57	240	0.09	---	0.47	241	0.00	6.95	0.83
2	North	3.0	13.4	172	7.38	0.035	0.11	172	0.02	7.48	0.20	245	0.00	---	0.21	192	0.16	7.19	0.38
2	North	3.0	16.3	166	7.54	0.100	0.29	168	0.00	7.12	0.21	243	0.02	---	0.31	157	0.02	7.14	0.16
2	North	3.0	19.2	208	7.48	0.015	0.02	198	0.00	6.98	0.03	222	0.02	---	0.10	158	0.04	7.13	0.15
2	North	3.0	22.1	222	7.23	0.095	1.22	181	0.86	6.64	0.28	189	0.23	---	0.11	120	3.24	6.51	0.36
2	North	3.0	25.0	206	7.27	0.045	0.21	155	0.10	7.03	0.11	210	0.25	---	0.07	123	1.55	6.18	0.10
2	North	3.0	27.9	179	7.56	0.050	0.03	132	0.02	7.56	0.03	197	0.05	---	0.07	129	0.14	6.70	0.02
2	North	3.0	30.8	121	7.19	0.075	0.05	94.1	0.01	7.40	0.00	179	0.03	---	0.00	126	0.11	7.01	0.02
2	North	3.0	33.7	114	7.06	0.030	0.02	86.8	0.00	7.11	0.00	150	0.05	---	0.00	103	0.15	6.93	0.00
2	North	3.0	36.6	129	6.54	0.025	0.02	91.6	0.02	7.02	0.00	146	0.04	---	0.00	118	0.14	6.85	0.00
2	North	3.0	39.5	103	5.91	2.160	0.00	103	4.38	6.05	0.29	145	0.89	---	0.02	180	3.50	6.15	0.24

Table 4. Field and laboratory chemical analysis of samples collected from permanent pond-bottom piezometers collected prior to, and 2, 11 and 23 months after barrier installation.

[Location of sites shown in figure 2. F shorthand for MA-FSW. Elevations of all permanently installed devices were determined on October 6, 2004 by the U.S. Geological Survey. μS/cm, microsiemens per centimeter at 25oC; <, actual value less than method detection limit; E, estimated value; ---, no data. Dissolved oxygen (less than 2 mg/L) was determined onsite using a colorimetric photometer. Dissolved oxygen greater than 2 mg/L was determined in the laboratory using a meter and electrode. Pond stage measured on 8/8/04, 11/3/04, 7/20/05, and 8/9/06 was 43.90, 43.43, 45.38, and 46.15 feet above NGVD of 1929, respectively. All phosphorus and nitrogen samples were analyzed at the USGS National Water Quality Laboratory.]

		Altitude of Water Level (ft)				Specific Conductance (μS/cm)				pH (standard units)				Oxygen, dissolved (mg/L)			
USGS Site Name	Bott. of Screen Altitude (ft)	8/4/04	11/3/04	7/20/05	8/9/06	8/4/04	11/3/04	7/20/05	8/9/06	8/4/04	11/3/04	7/20/05	8/9/06	8/4/04	11/3/04	7/20/05	8/9/06
F633P01-0010	34.02	44.080	43.610	45.515	46.288	108	127	176	196	5.98	6.03	6.42	6.14	0.130	8.90	0.035	0.005
F633P01-0030	14.44	44.113	43.620	45.563	46.330	162	147	187	177	6.75	6.55	6.87	6.28	0.065	2.73	0.005	0.025
F633P01-0060	-15.56	44.136	43.633	45.614	46.294	131	138	137	118	6.94	6.71	---	6.94	7.38	9.27	0.700	0.655
F633P01-0100	-55.56	44.162	43.640	45.663	---	65.8	85.1	75.3	76.3	6.83	7.14	---	8.24	5.38	5.54	8.53	0.575
F635P01-0010	31.65	44.005	---	---	46.291	184	191	133	102	6.67	6.61	6.37	6.17	0.005	0.615	5.67	0.050
F635P01-0030	6.65	44.054	43.558	45.505	46.284	104	176	107	95.6	6.63	6.29	6.36	6.06	0.010	0.275	0.165	0.135
F635P01-0060	-18.50	44.097	43.587	45.553	46.340	93.8	101	95.1	98.6	6.31	6.39	6.36	5.77	0.025	0.035	0.015	0.045
F635P01-0100	-58.60	44.107	43.607	45.569	46.366	79.6	76.5	71.5	72.7	6.38	6.47	6.07	5.50	0.220	0.070	8.41	8.84
F636P01-0010	26.30	44.035	43.522	45.492	46.278	109	111	116	107	6.30	6.08	6.04	5.98	0.120	0.700	0.000	0.245
F636P01-0030	6.30	44.044	43.532	45.515	46.294	105	106	117	91.6	6.55	6.33	6.03	5.43	0.130	0.625	1.12	8.74
F636P01-0060	-23.70	44.067	43.548	45.537	46.311	72.3	77.1	104	88.0	6.21	6.01	6.05	5.82	9.54	10.21	9.29	9.28
F636P01-0100	-63.70	44.077	43.545	45.409	46.291	144	91.3	114	102	6.65	5.89	6.00	5.76	5.18	9.32	7.35	7.64

Table 4. Field and laboratory chemical analysis of samples collected from permanent pond-bottom piezometers collected prior to, and 2, 11, and 23 months after barrier installation - *Continued*

		Phosphorus, dissolved (mg/L as P)				Nitrate, dissolved (mg/L as N)				Ammonium, dissolved (mg/L as N)			
USGS Site Name	Bott. of Screen Altitude (ft)	8/4/04	11/3/04	7/20/05	8/9/06	8/4/04	11/3/04	7/20/05	8/9/06	8/4/04	11/3/04	7/20/05	8/9/06
F633P01-0010	34.02	1.94	1.46	1.34	1.08	1.29	0.95	<0.06	<0.06	<0.04	<0.04	0.19	0.60
F633P01-0030	14.44	2.25	2.07	1.40	1.32	0.05	<0.06	<0.06	<0.06	1.16	1.16	1.04	0.63
F633P01-0060	-15.56	0.49	<0.02	E0.02	0.29	1.84	<0.06	<0.06	1.39	2.47	3.68	3.51	0.92
F633P01-0100	-55.56	<0.01	<0.02	<0.02	<0.02	0.75	0.49	<0.06	<0.06	<0.04	0.17	0.50	0.41
F635P01-0010	31.65	0.39	0.48	0.47	0.65	1.67	0.52	2.03	2.13	2.21	1.02	0.12	1.54
F635P01-0030	6.65	0.34	0.29	0.32	0.17	2.15	1.67	2.17	2.14	2.12	2.74	2.15	1.00
F635P01-0060	-18.50	0.03	0.03	0.03	0.03	2.87	2.78	2.40	2.49	1.89	1.74	1.51	0.88
F635P01-0100	-58.60	0.43	0.05	0.03	0.03	2.56	2.07	0.91	0.62	1.73	1.70	0.06	0.01
F636P01-0010	26.30	<0.01	<0.02	<0.02	E0.012	2.95	3.00	2.62	2.61	3.32	3.10	2.76	1.89
F636P01-0030	6.30	0.02	0.03	E0.01	<0.02	2.74	2.94	2.95	0.86	2.16	1.70	0.50	0.02
F636P01-0060	-23.70	0.16	<0.02	E0.01	<0.02	0.65	0.63	0.85	0.70	<0.04	0.04	0.04	0.01
F636P01-0100	-63.70	<0.01	<0.02	E0.02	<0.02	0.85	0.72	0.66	0.56	0.27	<0.04	E0.03	0.01

Table 5. Field seepage data and chemical analysis of samples collected 2, 11, and 23 months after barrier installation at permanent seepage meters installed the geochemical barrier.

[Location of sites shown in figure 2. Seepage meters 1a and 1b are located in the control area south of the geochemical barrier area. Paired meters are approximately 5 feet apart. Meters labeled " are on the southern side of the pair, "b" meters are on the north side. Each meter covers a pond-bottom area of 380 in^2 (2.64 ft^2). Field phosphate was determined onsite using a colorimetric method. ft, feet; min, minutes; ml, milliliters; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25°C; L/day, liters per day; mg/d, milligrams per day; ---, no analysis. Seepage results reported in letter dated 9/26/05 are included]

Meter Site No.	Water Depth (ft)	Date	Bag/valve No.	Total Time (min)	Total Volume (ml)	Specific Conductance (µS/cm)	Field Phosphate, dissolved (mg/L as P)	Water Flux (L/day)	Phosphorus Flux (mg/d)
1a	0.9	11/2/2004	1a	20	2620	185	0.42	188.6	80.0
	0.9	11/2/2004	1a	21	2550	181	0.44	174.9	77.0
	0.9	11/2/2004	1b	15	2320	---	---	227.7	---
							Average Water Flux (1a) for 11/2004:	**197.1**	
	2.8	7/18/2005	11	7	1150	110	---	236.6	---
	2.8	7/22/2005	11	17	2390	181	---	202.4	---
	2.8	7/22/2005	21	11	1660	177	---	217.3	---
	2.8	7/22/2005	11	11	1505	179	---	197.0	---
	2.8	7/22/2005	21	12	1830	180	0.80	219.6	175.5
							Average Water Flux (1a) for 7/2005:	**214.6**	
	3.4	8/8/2006	11	23	3615	157	---	226.3	---
	3.4	8/8/2006	21	15	2640	142	1.26	253.4	318.3
	3.4	8/8/2006	21	10	1580	136	---	227.5	---
	3.4	8/8/2006	11	10	1760	143	---	253.4	---
	3.4	8/8/2006	11	10	1570	136	---	226.1	---
							Average Water Flux (1a) for 8/2006:	**237.4**	
1b	0.9	11/2/2004	15	20	1210	215	0.55	87.1	47.9
	0.9	11/2/2004	16	21	1045	209	0.57	71.7	40.9
	0.9	11/2/2004	1a	15	1340	---	---	128.6	---
							Average Water Flux (1b) for 11/2004:	**95.8**	
	2.8	7/18/2005	6	7	570	107	---	117.3	---
	2.8	7/22/2005	21	17	1420	173	---	120.3	---
	2.8	7/22/2005	11	11	920	179	---	120.4	---
	2.8	7/22/2005	21	11	900	177	---	117.8	---
	2.8	7/22/2005	11	12	960	165	0.82	115.2	93.9
							Average Water Flux (1b) for 7/2005:	**118.20**	
	3.4	8/8/2006	21	23	2150	---	---	134.6	---
	3.4	8/8/2006	11	15	1235	115	1.30	118.6	154.7
	3.4	8/8/2006	11	10	660	113	---	95.0	---
	3.4	8/8/2006	21	10	1050	109	---	151.2	---
	3.4	8/8/2006	21	10	900	108	---	129.6	---
							Average Water Flux (1b) for 8/2006:	**125.8**	

Table 5. Field seepage data and chemical analysis of samples collected two and 11 months after barrier installation at permanent seepage meters installed the geochemical barrier -*Continued*

Meter Site No.	Water Depth (ft)	Date	Bag/valve No.	Total Time (min)	Total Volume (ml)	Specific Conductance (µS/cm)	Field Phosphate, dissolved (mg/L as P)	Water Flux (L/day)	Phosphorus Flux (mg/d)
2a	0	11/2/2004				Meter Dry			
						Average Water Flux (2b) for 11/2004:		**---**	
	1.8	7/18/2005	11	19	1160	97.0	---	87.9	---
	1.8	7/22/2005	15	15	940	190	---	90.2	---
	1.8	7/22/2005	10	14	950	187	---	97.7	---
	1.8	7/22/2005	15	11	1010	200	---	132.2	---
	1.8	7/22/2005	10	10	760	215	0.07	109.4	7.1
						Average Water Flux (2a) for 7/2005:		**103.5**	
	2.4	8/8/2006	1a	17	1160	167	---	98.3	---
	2.4	8/8/2006	10	15	1140	171	---	109.4	---
	2.4	8/8/2006	1a	17	1190	161	---	100.8	---
	2.4	8/8/2006	10	17	1250	166	---	105.9	---
	2.4	8/8/2006	1a	18	1120	157	0.03	89.6	2.9
						Average Water Flux (2a) for 8/2006:		**100.8**	
2b	0	11/2/2004				Meter Dry			
						Average Water Flux (2b) for 11/2004:		**---**	
	1.8	7/18/2005	11	18	1380	190	---	110.4	---
	1.8	7/22/2005	10	15	875	205	---	84.0	---
	1.8	7/22/2005	15	14	1060	218	---	109.0	---
	1.8	7/22/2005	10	11	750	209	---	98.2	---
	1.8	7/22/2005	15	10	815	259	0.03	117.4	3.8
						Average Water Flux (2b) for 7/2005:		**103.8**	
	2.4	8/8/2006	10	17	1180	168	---	100.0	---
	2.4	8/8/2006	1a	15	1050	172	---	100.8	---
	2.4	8/8/2006	10	17	1180	157	---	100.0	---
	2.4	8/8/2006	1a	17	1130	165	---	95.7	---
	2.4	8/8/2006	10	18	1110	164	0.02	88.8	1.5
						Average Water Flux (2b) for 8/8/2006:		**97.0**	

Table 5. Field seepage data and chemical analysis of samples collected two and 11 months after barrier installation at permanent seepage meters installed the geochemical barrier -*Continued*

Meter Site No.	Water Depth (ft)	Date	Bag/valve No.	Total Time (min)	Total Volume (ml)	Specific Conductance (µS/cm)	Field Phosphate, dissolved (mg/L as P)	Water Flux (L/day)	Phosphorus Flux (mg/d)
3a	0.5	11/2/2004	B	23	1625	214	0.05	101.7	5.1
	0.5	11/2/2004	B	22	1440	224	0.05	94.3	4.7
	0.5	11/2/2004	B	17	1100	223	0.07	93.2	6.5
	0.5	11/2/2004	6	20	1420	224	---	102.2	---
							Average Water Flux (3a) for 11/2004:	**97.9**	
	2.4	7/18/2005	36	11	510	101	---	66.8	---
	2.4	7/22/2005	3	17	1165	163	---	98.7	---
	2.4	7/22/2005	36	13	810	173	---	89.7	---
	2.4	7/22/2005	3	11	760	173	---	99.5	---
	2.4	7/22/2005	36	9	325	172	0.03	52.0	1.7
							Average Water Flux (3a) for 7/2005:	**81.3**	
	3.0	8/8/2006	1a	15	1040	142	0.05	99.8	4.9
	3.0	8/8/2006	8	15	965	144	---	92.6	---
	3.0	8/8/2006	1a	15	940	144	---	90.2	---
	3.0	8/8/2006	8	8	555	119	---	99.9	---
							Average Water Flux (3a) for 8/8/2006:	**95.6**	
3b	0.5	11/2/2004	13	23	1905	211	0.27	119.3	32.2
	0.5	11/2/2004	3	22	2725	217	0.33	178.4	58.2
	0.5	11/2/2004	3	17	2170	217	0.21	183.8	38.6
	0.5	11/2/2004	11	20	2420	---	---	174.2	---
							Average Water Flux (3b) for 11/2004:	**178.8**	
	2.4	7/18/2005	36	11	220	100	---	28.8	---
	2.4	7/22/2005	36	17	1010	166	---	85.6	---
	2.4	7/22/2005	3	13	1010	175	---	111.9	---
	2.4	7/22/2005	36	11	880	176	---	115.2	---
	2.4	7/22/2005	3	9	510	173	0.05	81.6	4.0
							Average Water Flux (3b) for 7/2005:	**98.6**	
	3.0	8/8/2006	8	15	1160	145	0.07	111.4	7.3
	3.0	8/8/2006	1a	15	630	134	---	60.5	---
	3.0	8/8/2006	8	15	1075	146	---	103.2	---
	3.0	8/8/2006	1a	8	565	132	---	101.7	---
							Average Water Flux (3b) for 8/8/2006:	**94.2**	

Table 5. Field seepage data and chemical analysis of samples collected two and 11 months after barrier installation at permanent seepage meters installed the geochemical barrier -*Continued*

Meter Site No.	Water Depth (ft)	Date	Bag/valve No.	Total Time (min)	Total Volume (ml)	Specific Conductance (µS/cm)	Field Phosphate, dissolved (mg/L as P)	Water Flux (L/day)	Phosphorus Flux (mg/d)
4a	0.95	11/2/2004	6	61	2845	161	0.02	67.2	1.3
	0.95	11/2/2004	11	31	1535	161	0.00	71.3	0.0
	0.95	11/2/2004	21	27	1390	162	0.00	74.1	0.0
	0.95	11/2/2004	36	25	1240	---	---	71.4	---
						Average Water Flux (4a) for 11/2004:		**71.0**	
	1.8	7/18/2005	21	17	755	96.3	---	64.0	---
	1.8	7/22/2005	8	19	840	95.8	---	63.7	---
	1.8	7/22/2005	17	15	750	109	---	72.0	---
	1.8	7/22/2005	8	14	720	105	---	74.1	---
	1.8	7/22/2005	17	9	230	---	0.26	36.8	9.6
						Average Water Flux (4a) for 7/2005:		**62.1**	
	3.2	8/8/2006	8	15	765	77.7	0.02	73.4	1.2
	3.2	8/8/2006	17	17	825	76.0	0.03	69.9	2.3
	3.2	8/8/2006	8	22	1080	78.2	0.02	70.7	1.2
	3.2	8/8/2006	17	20	990	76.9	0.08	71.3	5.8
						Average Water Flux (4a) for 8/8/2006:		**71.3**	
4b	1.0	11/2/2004	4	22	915	177	0.00	59.9	0.0
	1.0	11/2/2004	21	20	810	175	0.00	58.3	0.0
	1.0	11/2/2004	11	10	475	---	---	68.4	---
	1.0	11/2/2004	21	25	1020	---	---	58.8	---
						Average Water Flux (4b) for 11/2004:		**61.3**	
	1.8	7/18/2005	10	17	585	100	---	49.6	---
	1.8	7/22/2005	17	19	850	105	---	64.4	---
	1.8	7/22/2005	8	15	610	109	---	58.6	---
	1.8	7/22/2005	17	14	630	100	---	64.8	---
	1.8	7/22/2005	8	9	360	---	0.23	57.6	13.2
						Average Water Flux (4b) for 7/2005:		**59.0**	
	3.2	8/8/2006	17	15	595	93.6	0.05	57.1	2.8
	3.2	8/8/2006	8	17	635	95.2	0.10	53.8	5.3
	3.2	8/8/2006	17	22	800	95.9	0.00	52.4	0.0
	3.2	8/8/2006	8	20	765	95.1	---	58.3	---
						Average Water Flux (4b) for 8/8/2006:		**55.4**	

Table 6. Location and installation data for ground-water samples collected from a temporary drive points below the pond bottom, Ashumet Pond, August 2 - 21, 2006

[State plane coordinates were determined using global positioning system from North Atlantic Datum 1983 (NAD83). Coordinates were projected to North Atlantic Datum 1927 (NAD27) using a Geographical Information System (GIS).
Altitude is in feet relative to the National Geodetic Vertical Datum of 1929 (NGVD29). m, meters; ft, feet. Drive-point method: KV, KV Associates "macho sampler"; MHE, MHE push point.
Pond stage determined by measurement of USGS pond siphon gage located near the Fishermans Cove boat ramp.

USGS Station Name	USGS Site ID	USGS Location ID	Drive Depth (ft)	Date Sampled	NAD83 Easting (ft)	NAD83 Northing (m)	NAD27 Easting (ft)	NAD27 Northing (ft)	Distance from Shore (ft)	Pond Stage (ft above NGVD29)	Water Depth (ft)	Drive-Point Method	Screen Length (ft)	Alt. Top of Drive-Point Screen (ft above NGVD29)	Alt. Bott. of Drive-Point Screen (ft above NGVD29)
MA-FSW 669-A01	413804070322501	01-20	0.50	8/2/2006	279960.096	820930.300	862199.335	232665.936	20	46.15	3.25	MHE	0.13	42.53	42.40
MA-FSW 669-A01	413804070322501	01-20	3.00	8/2/2006	279960.096	820930.300	862199.335	232665.936	20	46.15	3.25	KV	0.4	40.30	39.90
MA-FSW 669-A02	413805070322411	02-20	0.50	8/3/2006	279981.284	820949.857	862268.851	232730.098	20	46.15	3.81	MHE	0.13	41.97	41.84
MA-FSW 669-A02	413805070322411	02-20	3.00	8/3/2006	279981.284	820949.857	862268.851	232730.098	20	46.15	3.81	KV	0.4	39.74	39.34
MA-FSW 669-A03	413804070322401	02-90	0.50	8/3/2006	279979.536	820929.851	862263.115	232664.461	90	46.15	4.81	MHE	0.13	40.97	40.84
MA-FSW 669-A03	413804070322401	02-90	3.00	8/3/2006	279979.536	820929.851	862263.115	232664.461	90	46.15	4.81	KV	0.4	38.74	38.34
MA-FSW 669-A04	413805070322314	03-20	0.50	8/3/2006	279999.319	820945.576	862328.021	232716.051	20	46.15	3.34	MHE	0.13	42.44	42.31
MA-FSW 669-A04	413805070322314	03-20	3.00	8/3/2006	279999.319	820945.576	862328.021	232716.051	20	46.15	3.34	KV	0.4	40.21	39.81
MA-FSW 669-A05	413804070322301	03-90	0.50	8/3/2006	280000.451	820926.413	862331.734	232653.180	90	46.15	5.40	MHE	0.13	40.38	40.25
MA-FSW 669-A05	413804070322301	03-90	3.00	8/3/2006	280000.451	820926.413	862331.734	232653.180	90	46.15	5.40	KV	0.4	38.15	37.75
MA-FSW 669-A06	413805070322215	04-00	0.50	8/3/2006	280025.862	820961.658	862415.105	232768.812	16	46.15	2.10	MHE	0.13	43.68	43.55
MA-FSW 669-A06	413805070322215	04-00	3.00	8/3/2006	280025.862	820961.658	862415.105	232768.812	16	46.15	2.10	KV	0.4	41.45	41.05
MA-FSW 669-A07	413805070322220	04-08	0.50	8/4/2006	280026.695	820960.285	862417.838	232764.307	24	46.15	2.69	MHE	0.13	43.09	42.96
MA-FSW 669-A07	413805070322220	04-08	3.00	8/4/2006	280026.695	820960.285	862417.838	232764.307	24	46.15	2.69	KV	0.4	40.86	40.46
MA-FSW 669-A08	413805070322216	04-16	0.50	8/4/2006	280028.180	820957.821	862422.710	232756.223	32	46.15	3.64	MHE	0.13	42.14	42.01
MA-FSW 669-A08	413805070322216	04-16	1.50	8/4/2006	280028.180	820957.821	862422.710	232756.223	32	46.15	3.64	KV	0.4	41.41	41.01
MA-FSW 669-A08	413805070322216	04-16	3.00	8/4/2006	280028.180	820957.821	862422.710	232756.223	32	46.15	3.64	KV	0.4	39.91	39.51
MA-FSW 669-A09	413805070322221	04-24	0.50	8/7/2006	280029.312	820955.941	862426.424	232750.055	40	46.08	3.80	MHE	0.13	41.91	41.78
MA-FSW 669-A09	413805070322221	04-24	3.00	8/7/2006	280029.312	820955.941	862426.424	232750.055	40	46.08	3.80	KV	0.4	39.68	39.28
MA-FSW 669-A10	413805070322217	04-35	0.50	8/7/2006	280031.140	820953.702	862432.421	232742.709	51	46.08	4.40	MHE	0.13	41.31	41.18
MA-FSW 669-A10	413805070322217	04-35	3.00	8/7/2006	280031.140	820953.702	862432.421	232742.709	51	46.08	4.40	KV	0.4	39.08	38.68
MA-FSW 669-A11	413806070322211	05-08	0.50	8/7/2006	280033.000	820964.929	862438.524	232779.543	22	46.08	2.50	MHE	0.13	43.21	43.08
MA-FSW 669-A11	413806070322211	05-08	3.00	8/7/2006	280033.000	820964.929	862438.524	232779.543	22	46.08	2.50	KV	0.4	40.98	40.58
MA-FSW 669-A12	413805070322218	05-24	0.50	8/7/2006	280037.378	820963.084	862452.887	232773.490	38	46.08	4.10	MHE	0.13	41.61	41.48
MA-FSW 669-A12	413805070322218	05-24	3.00	8/7/2006	280037.378	820963.084	862452.887	232773.490	38	46.08	4.10	KV	0.4	39.38	38.98
MA-FSW 669-A13	413805070322219	05-46	0.50	8/7/2006	280041.267	820957.395	862465.646	232754.825	60	46.08	4.76	MHE	0.13	40.95	40.82
MA-FSW 669-A13	413805070322219	05-46	3.00	8/7/2006	280041.267	820957.395	862465.646	232754.825	60	46.08	4.76	KV	0.4	38.72	38.32
MA-FSW 669-A14	413806070322212	06-00	0.50	8/7/2006	280040.500	820973.500	862463.130	232807.663	15	46.08	1.90	MHE	0.13	43.81	43.68
MA-FSW 669-A14	413806070322212	06-00	1.50	8/7/2006	280040.500	820973.500	862463.130	232807.663	15	46.08	1.90	KV	0.4	43.08	42.68
MA-FSW 669-A14	413806070322212	06-00	3.00	8/7/2006	280040.500	820973.500	862463.130	232807.663	15	46.08	1.90	KV	0.4	41.58	41.18
MA-FSW 669-A15	413806070322213	06-08	0.50	8/10/2006	280042.099	820971.659	862468.376	232801.622	23	46.02	2.45	MHE	0.13	43.20	43.07
MA-FSW 669-A15	413806070322213	06-08	1.50	8/10/2006	280042.099	820971.659	862468.376	232801.622	23	46.02	2.45	KV	0.4	42.47	42.07
MA-FSW 669-A15	413806070322213	06-08	3.00	8/10/2006	280042.099	820971.659	862468.376	232801.622	23	46.02	2.45	KV	0.4	40.97	40.57
MA-FSW 669-A16	413806070322214	06-16	0.50	8/10/2006	280043.900	820968.789	862474.285	232792.206	31	46.02	2.88	MHE	0.13	42.77	42.64
MA-FSW 669-A16	413806070322214	06-16	1.50	8/10/2006	280043.900	820968.789	862474.285	232792.206	31	46.02	2.88	KV	0.4	42.04	41.64
MA-FSW 669-A16	413806070322214	06-16	3.00	8/10/2006	280043.900	820968.789	862474.285	232792.206	31	46.02	2.88	KV	0.4	40.54	40.14
MA-FSW 669-A17	413806070322215	06-24	0.50	8/10/2006	280045.357	820967.445	862479.065	232787.797	39	46.02	3.17	MHE	0.13	42.48	42.35
MA-FSW 669-A17	413806070322215	06-24	1.50	8/10/2006	280045.357	820967.445	862479.065	232787.797	39	46.02	3.17	KV	0.4	41.75	41.35
MA-FSW 669-A17	413806070322215	06-24	3.00	8/10/2006	280045.357	820967.445	862479.065	232787.797	39	46.02	3.17	KV	0.4	40.25	39.85
MA-FSW 669-A18	413806070322101	06-35	0.50	8/14/2006	280047.581	820964.160	862486.362	232777.019	50	46.09	4.04	MHE	0.13	41.68	41.55
MA-FSW 669-A18	413806070322101	06-35	1.50	8/14/2006	280047.581	820964.160	862486.362	232777.019	50	46.09	4.04	KV	0.4	40.95	40.55
MA-FSW 669-A18	413806070322101	06-35	3.00	8/14/2006	280047.581	820964.160	862486.362	232777.019	50	46.09	4.04	KV	0.4	39.45	39.05
MA-FSW 669-A19	413805070322101	06-46	0.50	8/14/2006	280049.695	820962.915	862493.298	232772.934	61	46.09	5.20	MHE	0.13	40.52	40.39
MA-FSW 669-A19	413805070322101	06-46	3.00	8/14/2006	280049.695	820962.915	862493.298	232772.934	61	46.09	5.20	KV	0.4	38.29	37.89
MA-FSW 669-A20	413805070322102	06-57	0.50	8/14/2006	280051.893	820960.384	862500.509	232764.630	72	46.09	5.84	MHE	0.13	39.88	39.75
MA-FSW 669-A20	413805070322102	06-57	3.00	8/14/2006	280051.893	820960.384	862500.509	232764.630	72	46.09	5.84	KV	0.4	37.65	37.25
MA-FSW 669-A21	413806070322216	07-00	0.50	8/10/2006	280046.205	820979.522	862481.848	232827.419	11	46.02	1.38	MHE	0.13	44.27	44.14
MA-FSW 669-A21	413806070322216	07-00	1.50	8/10/2006	280046.205	820979.522	862481.848	232827.419	11	46.02	1.38	KV	0.4	43.54	43.14
MA-FSW 669-A21	413806070322216	07-00	3.00	8/10/2006	280046.205	820979.522	862481.848	232827.419	11	46.02	1.38	KV	0.4	42.04	41.64
MA-FSW 669-A22	413806070322102	07-08	0.50	8/10/2006	280046.809	820978.469	862483.829	232823.965	19	46.02	2.18	MHE	0.13	43.47	43.34
MA-FSW 669-A22	413806070322102	07-08	1.50	8/10/2006	280046.809	820978.469	862483.829	232823.965	19	46.02	2.18	KV	0.4	42.74	42.34
MA-FSW 669-A22	413806070322102	07-08	3.00	8/10/2006	280046.809	820978.469	862483.829	232823.965	19	46.02	2.18	KV	0.4	41.24	40.84
MA-FSW 669-A23	413806070322103	07-16	0.50	8/10/2006	280048.748	820976.482	862490.191	232817.446	27	46.02	2.79	MHE	0.13	42.86	42.73
MA-FSW 669-A23	413806070322103	07-16	1.50	8/10/2006	280048.748	820976.482	862490.191	232817.446	27	46.02	2.79	KV	0.4	42.13	41.73
MA-FSW 669-A23	413806070322103	07-16	3.00	8/10/2006	280048.748	820976.482	862490.191	232817.446	27	46.02	2.79	KV	0.4	40.63	40.23
MA-FSW 669-A24	413806070322104	07-24	0.50	8/10/2006	280051.291	820974.812	862498.534	232811.966	35	46.02	3.24	MHE	0.13	42.41	42.28
MA-FSW 669-A24	413806070322104	07-24	1.50	8/10/2006	280051.291	820974.812	862498.534	232811.966	35	46.02	3.24	KV	0.4	41.68	41.28
MA-FSW 669-A24	413806070322104	07-24	3.00	8/10/2006	280051.291	820974.812	862498.534	232811.966	35	46.02	3.24	KV	0.4	40.18	39.78
MA-FSW 669-A25	413806070322105	07-35	0.50	8/14/2006	280053.791	820971.829	862506.736	232802.179	46	46.09	4.10	MHE	0.13	41.62	41.49
MA-FSW 669-A25	413806070322105	07-35	1.50	8/14/2006	280053.791	820971.829	862506.736	232802.179	46	46.09	4.10	KV	0.4	40.89	40.49
MA-FSW 669-A25	413806070322105	07-35	3.00	8/14/2006	280053.791	820971.829	862506.736	232802.179	46	46.09	4.10	KV	0.4	39.39	38.99
MA-FSW 669-A26	413806070322106	07-46	0.50	8/14/2006	280056.019	820969.324	862514.046	232793.961	57	46.09	5.09	MHE	0.13	40.63	40.50
MA-FSW 669-A26	413806070322106	07-46	3.00	8/14/2006	280056.019	820969.324	862514.046	232793.961	57	46.09	5.09	KV	0.4	38.40	38.00
MA-FSW 669-A27	413806070322107	08-00	0.50	8/11/2006	280052.391	820984.732	862502.143	232844.512	16	46.02	2.00	MHE	0.13	43.65	43.52
MA-FSW 669-A27	413806070322107	08-00	1.50	8/11/2006	280052.391	820984.732	862502.143	232844.512	16	46.02	2.00	KV	0.4	42.92	42.52
MA-FSW 669-A27	413806070322107	08-00	3.00	8/11/2006	280052.391	820984.732	862502.143	232844.512	16	46.02	2.00	KV	0.4	41.42	41.02
MA-FSW 669-A28	413806070322108	08-08	0.50	8/11/2006	280054.354	820982.883	862508.584	232838.446	24	46.02	2.60	MHE	0.13	43.05	42.92
MA-FSW 669-A28	413806070322108	08-08	1.50	8/11/2006	280054.354	820982.883	862508.584	232838.446	24	46.02	2.60	KV	0.4	42.32	41.92
MA-FSW 669-A28	413806070322108	08-08	3.00	8/11/2006	280054.354	820982.883	862508.584	232838.446	24	46.02	2.60	KV	0.4	40.82	40.42
MA-FSW 669-A29	413806070322109	08-16	0.50	8/11/2006	280055.922	820981.954	862513.728	232835.398	32	46.02	3.39	MHE	0.13	42.26	42.13
MA-FSW 669-A29	413806070322109	08-16	1.50	8/11/2006	280055.922	820981.954	862513.728	232835.398	32	46.02	3.39	KV	0.4	41.53	41.13
MA-FSW 669-A29	413806070322109	08-16	3.00	8/11/2006	280055.922	820981.954	862513.728	232835.398	32	46.02	3.39	KV	0.4	40.03	39.63
MA-FSW 669-A30	413806070322110	08-24	0.50	8/11/2006	280057.803	820981.020	862519.899	232832.333	40	46.02	3.76	MHE	0.13	41.89	41.76
MA-FSW 669-A30	413806070322110	08-24	1.50	8/11/2006	280057.803	820981.020	862519.899	232832.333	40	46.02	3.76	KV	0.4	41.16	40.76
MA-FSW 669-A30	413806070322110	08-24	3.00	8/11/2006	280057.803	820981.020	862519.899	232832.333	40	46.02	3.76	KV	0.4	39.66	39.26
MA-FSW 669-A31	413806070322111	08-35	0.50	8/14/2006	280060.379	820978.509	862528.351	232824.095	51	46.09	4.20	MHE	0.13	41.52	41.39
MA-FSW 669-A31	413806070322111	08-35	1.50	8/14/2006	280060.379	820978.509	862528.351	232824.095	51	46.09	4.20	KV	0.4	40.79	40.39
MA-FSW 669-A31	413806070322111	08-35	3.00	8/14/2006	280060.379	820978.509	862528.351	232824.095	51	46.09	4.20	KV	0.4	39.29	38.89
MA-FSW 669-A32	413806070322112	08-46	0.50	8/14/2006	280062.636	820976.029	862535.755	232815.958	62	46.09	5.80	MHE	0.13	39.92	39.79
MA-FSW 669-A32	413806070322112	08-46	3.00	8/14/2006	280062.636	820976.029	862535.755	232815.958	62	46.09	5.80	KV	0.4	37.69	37.29
MA-FSW 669-A33	413806070322119	08-57	0.50	8/14/2006	280064.892	820973.549	862543.157	232807.822	73	46.09	6.00	MHE	0.13	39.72	39.59
MA-FSW 669-A33	413806070322119	08-57	3.00	8/14/2006	280064.892	820973.549	862543.157	232807.822	73	46.09	6.00	KV	0.4	37.49	37.09
MA-FSW 669-A34	413806070322113	09-00	0.50	8/14/2006	280059.618	820991.891	862525.854	232867.999	19	46.09	1.96	MHE	0.13	43.76	43.63
MA-FSW 669-A34	413806070322113	09-00	1.50	8/14/2006	280059.618	820991.891	862525.854	232867.999	19	46.09	1.96	KV	0.4	43.03	42.63
MA-FSW 669-A34	413806070322113	09-00	3.00	8/14/2006	280059.618	820991.891	862525.854	232867.999	19	46.09	1.96	KV	0.4	41.53	41.13
MA-FSW 669-A35	413806070322114	09-08	0.50	8/15/2006	280061.823	820990.924	862533.088	232864.827	27	46.10	2.80	MHE	0.13	42.93	42.80
MA-FSW 669-A35	413806070322114	09-08	1.50	8/15/2006	280061.823	820990.924	862533.088	232864.827	27	46.10	2.80	KV	0.4	42.20	41.80
MA-FSW 669-A35	413806070322114	09-08	3.00	8/15/2006	280061.823	820990.924	862533.088	232864.827	27	46.10	2.80	KV	0.4	40.70	40.30
MA-FSW 669-A36	413806070322115	09-16	0.50	8/15/2006	280063.995	820990.307	862540.214	232862.802	35	46.10	3.30	MHE	0.13	42.43	42.30

USGS Station Name	USGS Site ID	USGS Location ID	Drive Depth (ft)	Date Sampled	NAD83 Easting (ft)	NAD83 Northing (m)	NAD27 Easting (ft)	NAD27 Northing (ft)	Distance from Shore (ft)	Pond Stage (ft above NGVD29)	Water Depth (ft)	Drive-Point Method	Screen Length (ft)	Alt. Top of Drive-Point Screen (ft above NGVD29)	Alt. Bott. of Drive-Point Screen (ft above NGVD29)
MA-FSW 669-A36	413806070322115	09-16	1.50	8/15/2006	280063.995	820990.307	862540.214	232862.802	35	46.10	3.30	KV	0.4	41.70	41.30
MA-FSW 669-A36	413806070322115	09-16	3.00	8/15/2006	280063.995	820990.307	862540.214	232862.802	35	46.10	3.30	KV	0.4	40.20	39.80
MA-FSW 669-A37	413806070322116	09-24	0.50	8/15/2006	280064.307	820988.165	862541.238	232855.775	43	46.10	3.60	MHE	0.13	42.13	42.00
MA-FSW 669-A37	413806070322116	09-24	1.50	8/15/2006	280064.307	820988.165	862541.238	232855.775	43	46.10	3.60	KV	0.4	41.40	41.00
MA-FSW 669-A37	413806070322116	09-24	3.00	8/15/2006	280064.307	820988.165	862541.238	232855.775	43	46.10	3.60	KV	0.4	39.90	39.50
MA-FSW 669-A38	413806070322117	09-35	0.50	8/15/2006	280067.999	820985.353	862553.351	232846.548	54	46.10	4.10	MHE	0.13	41.63	41.50
MA-FSW 669-A38	413806070322117	09-35	1.50	8/15/2006	280067.999	820985.353	862553.351	232846.548	54	46.10	4.10	KV	0.4	40.90	40.50
MA-FSW 669-A38	413806070322117	09-35	3.00	8/15/2006	280067.999	820985.353	862553.351	232846.548	54	46.10	4.10	KV	0.4	39.40	39.00
MA-FSW 669-A39	413806070322118	09-46	0.50	8/15/2006	280071.542	820984.465	862564.975	232843.635	65	46.10	5.35	MHE	0.13	40.38	40.25
MA-FSW 669-A39	413806070322118	09-46	3.00	8/15/2006	280071.542	820984.465	862564.975	232843.635	65	46.10	5.35	KV	0.4	38.15	37.75
MA-FSW 669-A40	413807070322101	10-00	0.50	8/15/2006	280062.453	820998.465	862535.156	232889.567	14	46.10	1.85	MHE	0.13	43.88	43.75
MA-FSW 669-A40	413807070322101	10-00	1.50	8/15/2006	280062.453	820998.465	862535.156	232889.567	14	46.10	1.85	KV	0.4	43.15	42.75
MA-FSW 669-A40	413807070322101	10-00	3.00	8/15/2006	280062.453	820998.465	862535.156	232889.567	14	46.10	1.85	KV	0.4	41.65	41.25
MA-FSW 669-A41	413807070322102	10-08	0.50	8/15/2006	280064.341	820997.533	862541.350	232886.509	22	46.10	2.34	MHE	0.13	43.39	43.26
MA-FSW 669-A41	413807070322102	10-08	1.50	8/15/2006	280064.341	820997.533	862541.350	232886.509	22	46.10	2.34	KV	0.4	42.66	42.26
MA-FSW 669-A41	413807070322102	10-08	3.00	8/15/2006	280064.341	820997.533	862541.350	232886.509	22	46.10	2.34	KV	0.4	41.16	40.76
MA-FSW 669-A42	413807070322103	10-16	0.50	8/15/2006	280066.592	820996.178	862548.735	232882.064	30	46.10	3.14	MHE	0.13	42.59	42.46
MA-FSW 669-A42	413807070322103	10-16	1.50	8/15/2006	280066.592	820996.178	862548.735	232882.064	30	46.10	3.14	KV	0.4	41.86	41.46
MA-FSW 669-A42	413807070322103	10-16	3.00	8/15/2006	280066.592	820996.178	862548.735	232882.064	30	46.10	3.14	KV	0.4	40.36	39.96
MA-FSW 669-A43	413806070322001	10-24	0.50	8/15/2006	280069.058	820994.776	862556.825	232877.464	38	46.10	3.65	MHE	0.13	42.08	41.95
MA-FSW 669-A43	413806070322001	10-24	1.50	8/15/2006	280069.058	820994.776	862556.825	232877.464	38	46.10	3.65	KV	0.4	41.35	40.95
MA-FSW 669-A43	413806070322001	10-24	3.00	8/15/2006	280069.058	820994.776	862556.825	232877.464	38	46.10	3.65	KV	0.4	39.85	39.45
MA-FSW 669-A44	413806070322002	10-35	0.50	8/15/2006	280071.391	820993.073	862564.480	232871.876	49	46.10	4.50	MHE	0.13	41.23	41.10
MA-FSW 669-A44	413806070322002	10-35	1.50	8/15/2006	280071.391	820993.073	862564.480	232871.876	49	46.10	4.50	KV	0.4	40.50	40.10
MA-FSW 669-A44	413806070322002	10-35	3.00	8/15/2006	280071.391	820993.073	862564.480	232871.876	49	46.10	4.50	KV	0.4	39.00	38.60
MA-FSW 669-A45	413806070322003	10-46	0.50	8/16/2006	280074.462	820991.783	862574.555	232867.644	60	46.10	5.30	MHE	0.13	40.43	40.30
MA-FSW 669-A45	413806070322003	10-46	3.00	8/16/2006	280074.462	820991.783	862574.555	232867.644	60	46.10	5.30	KV	0.4	38.20	37.80
MA-FSW 669-A46	413806070322004	10-57	0.50	8/16/2006	280077.278	820989.200	862583.794	232859.169	71	46.10	6.03	MHE	0.13	39.70	39.57
MA-FSW 669-A46	413806070322004	10-57	1.50	8/16/2006	280077.278	820989.200	862583.794	232859.169	71	46.10	6.03	KV	0.4	38.97	38.57
MA-FSW 669-A46	413806070322004	10-57	3.00	8/16/2006	280077.278	820989.200	862583.794	232859.169	71	46.10	6.03	KV	0.4	37.47	37.07
MA-FSW 669-A47	413807070322104	11-00	0.50	8/16/2006	280068.298	821007.407	862554.332	232918.904	15	46.10	1.57	MHE	0.13	44.16	44.03
MA-FSW 669-A47	413807070322104	11-00	1.50	8/16/2006	280068.298	821007.407	862554.332	232918.904	15	46.10	1.57	KV	0.4	43.43	43.03
MA-FSW 669-A47	413807070322104	11-00	3.00	8/16/2006	280068.298	821007.407	862554.332	232918.904	15	46.10	1.57	KV	0.4	41.93	41.53
MA-FSW 669-A48	413807070322001	11-08	0.50	8/16/2006	280070.014	821006.467	862559.962	232915.820	23	46.10	2.50	MHE	0.13	43.23	43.10
MA-FSW 669-A48	413807070322001	11-08	1.50	8/16/2006	280070.014	821006.467	862559.962	232915.820	23	46.10	2.50	KV	0.4	42.50	42.10
MA-FSW 669-A48	413807070322001	11-08	3.00	8/16/2006	280070.014	821006.467	862559.962	232915.820	23	46.10	2.50	KV	0.4	41.00	40.60
MA-FSW 669-A49	413807070322002	11-16	0.50	8/16/2006	280072.216	821004.448	862567.187	232909.196	31	46.10	3.16	MHE	0.13	42.57	42.44
MA-FSW 669-A49	413807070322002	11-16	1.50	8/16/2006	280072.216	821004.448	862567.187	232909.196	31	46.10	3.16	KV	0.4	41.84	41.44
MA-FSW 669-A49	413807070322002	11-16	3.00	8/16/2006	280072.216	821004.448	862567.187	232909.196	31	46.10	3.16	KV	0.4	40.34	39.94
MA-FSW 669-A50	413807070322003	11-24	0.50	8/16/2006	280074.122	821003.069	862573.440	232904.672	39	46.10	3.68	MHE	0.13	42.05	41.92
MA-FSW 669-A50	413807070322003	11-24	1.50	8/16/2006	280074.122	821003.069	862573.440	232904.672	39	46.10	3.68	KV	0.4	41.32	40.92
MA-FSW 669-A50	413807070322003	11-24	3.00	8/16/2006	280074.122	821003.069	862573.440	232904.672	39	46.10	3.68	KV	0.4	39.82	39.42
MA-FSW 669-A51	413807070322004	11-35	0.50	8/16/2006	280076.609	821001.064	862581.599	232898.093	50	46.10	3.89	MHE	0.13	41.84	41.71
MA-FSW 669-A51	413807070322004	11-35	1.50	8/16/2006	280076.609	821001.064	862581.599	232898.093	50	46.10	3.89	KV	0.4	41.11	40.71
MA-FSW 669-A51	413807070322004	11-35	3.00	8/16/2006	280076.609	821001.064	862581.599	232898.093	50	46.10	3.89	KV	0.4	39.61	39.21
MA-FSW 669-A52	413807070322005	11-46	0.50	8/16/2006	280080.063	820999.505	862592.931	232892.978	61	46.10	5.05	MHE	0.13	40.68	40.55
MA-FSW 669-A52	413807070322005	11-46	3.00	8/16/2006	280080.063	820999.505	862592.931	232892.978	61	46.10	5.05	KV	0.4	38.45	38.05
MA-FSW 669-A53	413807070322020	11-57	0.50	8/16/2006	280082.478	820998.539	862600.855	232889.809	72	46.10	5.80	MHE	0.13	39.93	39.80
MA-FSW 669-A53	413807070322020	11-57	3.00	8/16/2006	280082.478	820998.539	862600.855	232889.809	72	46.10	5.80	KV	0.4	37.70	37.30
MA-FSW 669-A54	413807070322006	12-00	0.50	8/17/2006	280073.317	821014.906	862570.799	232943.507	12	46.04	1.55	MHE	0.13	44.12	43.99
MA-FSW 669-A54	413807070322006	12-00	1.50	8/17/2006	280073.317	821014.906	862570.799	232943.507	12	46.04	1.55	KV	0.4	43.39	42.99
MA-FSW 669-A54	413807070322006	12-00	3.00	8/17/2006	280073.317	821014.906	862570.799	232943.507	12	46.04	1.55	KV	0.4	41.89	41.49
MA-FSW 669-A55	413807070322007	12-08	0.50	8/17/2006	280075.350	821013.263	862577.469	232938.116	20	46.04	2.55	MHE	0.13	43.12	42.99
MA-FSW 669-A55	413807070322007	12-08	1.50	8/17/2006	280075.350	821013.263	862577.469	232938.116	20	46.04	2.55	KV	0.4	42.39	41.99
MA-FSW 669-A55	413807070322007	12-08	3.00	8/17/2006	280075.350	821013.263	862577.469	232938.116	20	46.04	2.55	KV	0.4	40.89	40.49
MA-FSW 669-A56	413807070322008	12-16	0.50	8/17/2006	280077.139	821012.271	862583.338	232934.862	28	46.04	3.13	MHE	0.13	42.54	42.41
MA-FSW 669-A56	413807070322008	12-16	1.50	8/17/2006	280077.139	821012.271	862583.338	232934.862	28	46.04	3.13	KV	0.4	41.81	41.41
MA-FSW 669-A56	413807070322008	12-16	3.00	8/17/2006	280077.139	821012.271	862583.338	232934.862	28	46.04	3.13	KV	0.4	40.31	39.91
MA-FSW 669-A57	413807070322009	12-24	0.50	8/17/2006	280079.048	821010.863	862589.602	232930.242	36	46.04	3.55	MHE	0.13	42.12	41.99
MA-FSW 669-A57	413807070322009	12-24	1.50	8/17/2006	280079.048	821010.863	862589.602	232930.242	36	46.04	3.55	KV	0.4	41.39	40.99
MA-FSW 669-A57	413807070322009	12-24	3.00	8/17/2006	280079.048	821010.863	862589.602	232930.242	36	46.04	3.55	KV	0.4	39.89	39.49
MA-FSW 669-A58	413807070322010	12-35	0.50	8/17/2006	280081.681	821009.148	862598.240	232924.615	42	46.04	3.90	MHE	0.13	41.77	41.64
MA-FSW 669-A58	413807070322010	12-35	1.50	8/17/2006	280081.681	821009.148	862598.240	232924.615	42	46.04	3.90	KV	0.4	41.04	40.64
MA-FSW 669-A58	413807070322010	12-35	3.00	8/17/2006	280081.681	821009.148	862598.240	232924.615	42	46.04	3.90	KV	0.4	39.54	39.14
MA-FSW 669-A59	413807070322011	12-46	0.50	8/17/2006	280085.037	821007.391	862609.251	232918.851	53	46.04	5.00	MHE	0.13	40.67	40.54
MA-FSW 669-A59	413807070322011	12-46	3.00	8/17/2006	280085.037	821007.391	862609.251	232918.851	53	46.04	5.00	KV	0.4	38.44	38.04
MA-FSW 669-A60	413807070322012	12-57	0.50	8/17/2006	280087.353	821004.951	862616.849	232910.845	64	46.04	5.90	MHE	0.13	39.77	39.64
MA-FSW 669-A60	413807070322012	12-57	3.00	8/17/2006	280087.353	821004.951	862616.849	232910.845	64	46.04	5.90	KV	0.4	37.54	37.14
MA-FSW 669-A61	413807070322013	13-00	0.50	8/17/2006	280076.879	821022.458	862582.486	232968.284	15	46.04	1.30	MHE	0.13	44.37	44.24
MA-FSW 669-A61	413807070322013	13-00	1.50	8/17/2006	280076.879	821022.458	862582.486	232968.284	15	46.04	1.30	KV	0.4	43.64	43.24
MA-FSW 669-A61	413807070322013	13-00	3.00	8/17/2006	280076.879	821022.458	862582.486	232968.284	15	46.04	1.30	KV	0.4	42.14	41.74
MA-FSW 669-A62	413807070322014	13-10	0.50	8/18/2006	280078.899	821021.334	862589.113	232964.596	23	46.04	2.60	MHE	0.13	43.07	42.94
MA-FSW 669-A62	413807070322014	13-10	1.50	8/18/2006	280078.899	821021.334	862589.113	232964.596	23	46.04	2.60	KV	0.4	42.34	41.94
MA-FSW 669-A62	413807070322014	13-10	3.00	8/18/2006	280078.899	821021.334	862589.113	232964.596	23	46.04	2.60	KV	0.4	40.84	40.44
MA-FSW 669-A63	413807070322015	13-16	0.50	8/18/2006	280080.941	821021.079	862595.813	232963.759	31	46.04	3.30	MHE	0.13	42.37	42.24
MA-FSW 669-A63	413807070322015	13-16	1.50	8/18/2006	280080.941	821021.079	862595.813	232963.759	31	46.04	3.30	KV	0.4	41.64	41.24
MA-FSW 669-A63	413807070322015	13-16	3.00	8/18/2006	280080.941	821021.079	862595.813	232963.759	31	46.04	3.30	KV	0.4	40.14	39.74
MA-FSW 669-A64	413807070322016	13-24	0.50	8/18/2006	280083.031	821018.970	862602.669	232956.840	39	46.04	3.65	MHE	0.13	42.02	41.89
MA-FSW 669-A64	413807070322016	13-24	1.50	8/18/2006	280083.031	821018.970	862602.669	232956.840	39	46.04	3.65	KV	0.4	41.29	40.89
MA-FSW 669-A64	413807070322016	13-24	3.00	8/18/2006	280083.031	821018.970	862602.669	232956.840	39	46.04	3.65	KV	0.4	39.79	39.39
MA-FSW 669-A65	413807070322017	13-35	0.50	8/18/2006	280086.094	821016.757	862612.719	232949.579	50	46.04	4.00	MHE	0.13	41.67	41.54
MA-FSW 669-A65	413807070322017	13-35	1.50	8/18/2006	280086.094	821016.757	862612.719	232949.579	50	46.04	4.00	KV	0.4	40.94	40.54
MA-FSW 669-A65	413807070322017	13-35	3.00	8/18/2006	280086.094	821016.757	862612.719	232949.579	50	46.04	4.00	KV	0.4	39.44	39.04
MA-FSW 669-A66	413807070322018	13-46	0.50	8/18/2006	280089.082	821016.913	862622.522	232950.090	61	46.04	4.80	MHE	0.13	40.87	40.74
MA-FSW 669-A66	413807070322018	13-46	3.00	8/18/2006	280089.082	821016.913	862622.522	232950.090	61	46.04	4.80	KV	0.4	38.64	38.24
MA-FSW 669-A67	413808070322001	14-00	0.50	8/18/2006	280080.370	821030.239	862593.939	232993.812	14	46.04	1.30	MHE	0.13	44.37	44.24
MA-FSW 669-A67	413808070322001	14-00	1.50	8/18/2006	280080.370	821030.239	862593.939	232993.812	14	46.04	1.30	KV	0.4	43.64	43.24
MA-FSW 669-A67	413808070322001	14-00	3.00	8/18/2006	280080.370	821030.239	862593.939	232993.812	14	46.04	1.30	KV	0.4	42.14	41.74
MA-FSW 669-A68	413808070322002	14-11	0.50	8/18/2006	280082.449	821029.640	862600.760	232991.846	22	46.04	2.60	MHE	0.13	43.07	42.94
MA-FSW 669-A68	413808070322002	14-11	1.50	8/18/2006	280082.449	821029.640	862600.760	232991.846	22	46.04	2.60	KV	0.4	42.34	41.94
MA-FSW 669-A68	413808070322002	14-11	3.00	8/18/2006	280082.449	821029.640	862600.760	232991.846	22	46.04	2.60	KV	0.4	40.84	40.44
MA-FSW 669-A69	413808070322003	14-16	0.50	8/21/2006	280085.939	821028.091	862612.210	232986.764	30	46.04	3.30	MHE	0.13	42.37	42.24
MA-FSW 669-A69	413808070322003	14-16	1.50	8/21/2006	280085.939	821028.091	862612.210	232986.764	30	46.04	3.30	KV	0.4	41.64	41.24

USGS Station Name	USGS Site ID	USGS Location ID	Drive Depth (ft)	Date Sampled	NAD83 Easting (ft)	NAD83 Northing (m)	NAD27 Easting (ft)	NAD27 Northing (ft)	Distance from Shore (ft)	Pond Stage (ft above NGVD29)	Water Depth (ft)	Drive-Point Method	Screen Length (ft)	Alt. Top of Drive-Point Screen (ft above NGVD29)	Alt. Bott. of Drive-Point Screen (ft above NGVD29)
MA-FSW 669-A69	413808070322003	14-16	3.00	8/21/2006	280085.939	821028.091	862612.210	232986.764	30	46.04	3.30	KV	0.4	40.14	39.74
MA-FSW 669-A70	413808070322004	14-24	0.50	8/21/2006	280087.588	821028.380	862617.621	232987.712	38	46.04	3.90	MHE	0.13	41.77	41.64
MA-FSW 669-A70	413808070322004	14-24	1.50	8/21/2006	280087.588	821028.380	862617.621	232987.712	38	46.04	3.90	KV	0.4	41.04	40.64
MA-FSW 669-A70	413808070322004	14-24	3.00	8/21/2006	280087.588	821028.380	862617.621	232987.712	38	46.04	3.90	KV	0.4	39.54	39.14
MA-FSW 669-A71	413807070322019	14-35	0.50	8/21/2006	280090.195	821025.944	862626.174	232979.720	49	46.04	4.00	MHE	0.13	41.67	41.54
MA-FSW 669-A71	413807070322019	14-35	1.50	8/21/2006	280090.195	821025.944	862626.174	232979.720	49	46.04	4.00	KV	0.4	40.94	40.54
MA-FSW 669-A71	413807070322019	14-35	3.00	8/21/2006	280090.195	821025.944	862626.174	232979.720	49	46.04	4.00	KV	0.4	39.44	39.04
MA-FSW 669-A72	413807070321901	14-46	0.50	8/21/2006	280093.475	821024.636	862636.935	232975.428	60	46.04	4.60	MHE	0.13	41.07	40.94
MA-FSW 669-A72	413807070321901	14-46	1.50	8/21/2006	280093.475	821024.636	862636.935	232975.428	60	46.04	4.60	KV	0.4	40.34	39.94
MA-FSW 669-A72	413807070321901	14-46	3.00	8/21/2006	280093.475	821024.636	862636.935	232975.428	60	46.04	4.60	KV	0.4	38.84	38.44
MA-FSW 669-A73	413807070321902	14-57	0.50	8/21/2006	280098.067	821022.283	862652.000	232967.708	71	46.03	5.90	MHE	0.13	39.76	39.63
MA-FSW 669-A73	413807070321902	14-57	3.00	8/21/2006	280098.067	821022.283	862652.000	232967.708	71	46.03	5.90	KV	0.4	37.53	37.13
MA-FSW 669-A74	413808070322005	15-00	0.50	8/21/2006	280085.037	821038.745	862609.251	233021.718	15	46.03	1.70	MHE	0.13	43.96	43.83
MA-FSW 669-A74	413808070322005	15-00	3.00	8/21/2006	280085.037	821038.745	862609.251	233021.718	15	46.03	1.70	KV	0.4	41.73	41.33
MA-FSW 669-A75	413808070322006	15-16	0.50	8/21/2006	280089.772	821036.148	862624.786	233013.198	31	46.03	3.20	MHE	0.13	42.46	42.33
MA-FSW 669-A75	413808070322006	15-16	3.00	8/21/2006	280089.772	821036.148	862624.786	233013.198	31	46.03	3.20	KV	0.4	40.23	39.83
MA-FSW 669-A76	413808070321901	15-35	0.50	8/21/2006	280094.167	821034.015	862639.205	233006.199	50	46.03	4.60	MHE	0.13	41.06	40.93
MA-FSW 669-A76	413808070321901	15-35	3.00	8/21/2006	280094.167	821034.015	862639.205	233006.199	50	46.03	4.60	KV	0.4	38.83	38.43

Additional Push Points Near the Shoreline - Field Measurements Only

---	---	04-(-04)	0.50	8/28/06	280024.763	820964.784	862411.499	232779.068	12	46.03	1.37	MHE	0.13	44.30	44.17
---	---	04-(-08)	0.50	8/28/06	280024.026	820965.868	862409.081	232782.624	8	46.03	0.91	MHE	0.13	44.75	44.62
---	---	04-(-12)	0.50	8/28/06	280023.289	820966.951	862406.663	232786.178	4	46.03	0.46	MHE	0.13	45.21	45.08
---	---	05-(-04)	0.50	8/28/06	280032.254	820972.850	862436.076	232805.531	10	46.03	1.08	MHE	0.13	44.58	44.45
---	---	05-(-08)	0.50	8/28/06	280032.776	820971.075	862437.789	232799.707	6	46.03	0.65	MHE	0.13	45.01	44.88
---	---	05-(-12)	0.50	8/28/06	280033.475	820969.815	862440.082	232795.573	0	46.03	0.00	MHE	0.13	45.66	45.53
---	---	06-(-04)	0.50	8/28/06	280042.689	820973.644	862470.312	232808.135	11	46.03	0.99	MHE	0.13	44.67	44.54
---	---	06-(-08)	0.50	8/28/06	280040.987	820974.710	862464.728	232811.632	7	46.03	0.63	MHE	0.13	45.03	44.90
---	---	06-(-12)	0.50	8/28/06	280038.912	820975.988	862457.920	232815.826	3	46.03	0.27	MHE	0.13	45.39	45.26
---	---	07-(-04)	0.50	8/28/06	280048.191	820980.064	862488.364	232829.198	7	46.03	0.65	MHE	0.13	45.01	44.88
---	---	07-(-08)	0.50	8/28/06	280046.482	820980.996	862482.757	232832.255	3	46.03	0.28	MHE	0.13	45.38	45.25
---	---	07-(-12)	0.50	8/28/06	280045.323	820981.702	862478.954	232834.572	0	46.03	0.00	MHE	0.13	45.66	45.53
---	---	08-(-04)	0.50	8/28/06	280055.197	820983.768	862511.349	232841.349	12	46.03	0.99	MHE	0.13	44.67	44.54
---	---	08-(-08)	0.50	8/28/06	280052.583	820985.370	862502.773	232846.605	8	46.03	0.66	MHE	0.13	45.00	44.87
---	---	08-(-12)	0.50	8/28/06	280050.044	820987.068	862494.443	232852.176	4	46.03	0.33	MHE	0.13	45.33	45.20
---	---	09-(-04)	0.50	8/28/06	280059.547	820990.308	862525.621	232862.806	15	46.03	1.23	MHE	0.13	44.43	44.30
---	---	09-(-08)	0.50	8/28/06	280057.621	820991.641	862519.302	232867.179	11	46.03	0.91	MHE	0.13	44.76	44.63
---	---	09-(-12)	0.50	8/28/06	280055.139	820993.569	862511.159	232873.505	7	46.03	0.58	MHE	0.13	45.08	44.95
---	---	10-(-04)	0.50	8/28/06	280065.212	820997.452	862544.207	232886.244	10	46.03	0.85	MHE	0.13	44.81	44.68
---	---	10-(-08)	0.50	8/28/06	280062.996	820998.274	862536.937	232888.941	6	46.03	0.51	MHE	0.13	45.15	45.02
---	---	10-(-12)	0.50	8/28/06	280061.358	820999.269	862531.563	232892.205	2	46.03	0.17	MHE	0.13	45.49	45.36
---	---	11-(-04)	0.50	8/28/06	280070.379	821005.317	862561.160	232912.047	11	46.03	0.89	MHE	0.13	44.77	44.64
---	---	11-(-08)	0.50	8/28/06	280067.950	821006.535	862553.191	232916.043	7	46.03	0.56	MHE	0.13	45.10	44.97
---	---	11-(-12)	0.50	8/28/06	280065.683	821008.120	862545.753	232921.244	3	46.03	0.24	MHE	0.13	45.42	45.29
---	---	12-(-04)	0.50	8/28/06	280071.866	821012.684	862566.039	232936.217	8	46.03	0.74	MHE	0.13	44.92	44.79
---	---	12-(-08)	0.50	8/28/06	280071.188	821013.325	862563.814	232938.320	4	46.03	0.37	MHE	0.13	45.29	45.16
---	---	12-(-12)	0.50	8/28/06	280067.028	821014.343	862550.166	232941.660	0	46.03	0.00	MHE	0.13	45.66	45.53
---	---	13-(-04)	0.50	8/28/06	280081.528	821021.645	862597.738	232965.616	11	46.03	0.87	MHE	0.13	44.79	44.66
---	---	13-(-08)	0.50	8/28/06	280076.962	821023.181	862582.758	232970.656	7	46.03	0.55	MHE	0.13	45.11	44.98
---	---	13-(-12)	0.50	8/28/06	280075.789	821022.236	862578.910	232967.555	3	46.03	0.24	MHE	0.13	45.42	45.29
---	---	14-(-04)	0.50	8/28/06	280080.869	821026.033	862595.576	232980.012	10	46.03	0.83	MHE	0.13	44.83	44.70
---	---	14-(-08)	0.50	8/28/06	280078.977	821026.594	862589.369	232981.853	6	46.03	0.50	MHE	0.13	45.16	45.03
---	---	14-(-12)	0.50	8/28/06	280076.478	821027.946	862581.170	232986.289	2	46.03	0.17	MHE	0.13	45.49	45.36
---	---	15-(-04)	0.50	8/28/06	280082.796	821035.768	862601.899	233011.951	11	46.03	1.01	MHE	0.13	44.65	44.52
---	---	15-(-08)	0.50	8/28/06	280081.629	821037.375	862598.070	233017.224	7	46.03	0.64	MHE	0.13	45.02	44.89
---	---	15-(-12)	0.50	8/28/06	280078.752	821038.996	862588.631	233022.542	3	46.03	0.28	MHE	0.13	45.38	45.25

Table 7. Field and laboratory chemical analyses from ground-water samples collected from a temporary drive point below the pond bottom, Ashumet Pond, August 2 - 21, 2006

[All phosphorus and nitrogen samples were analyzed at the USGS National Water Quality Laboratory. µS/cm, microsiemens per centimeter at 25 °C; mg/L, milligrams per liter.
Dissolved oxygen (less than 2 mg/L) and field phosphate were determined onsite using a colorimetric photometer. Dissolved oxygen greater than 2 mg/L was determined in the laboratory using a meter and electrode.
<, value less than laboratory reporting limit; E, estimated value; ---, sample not analyzed]

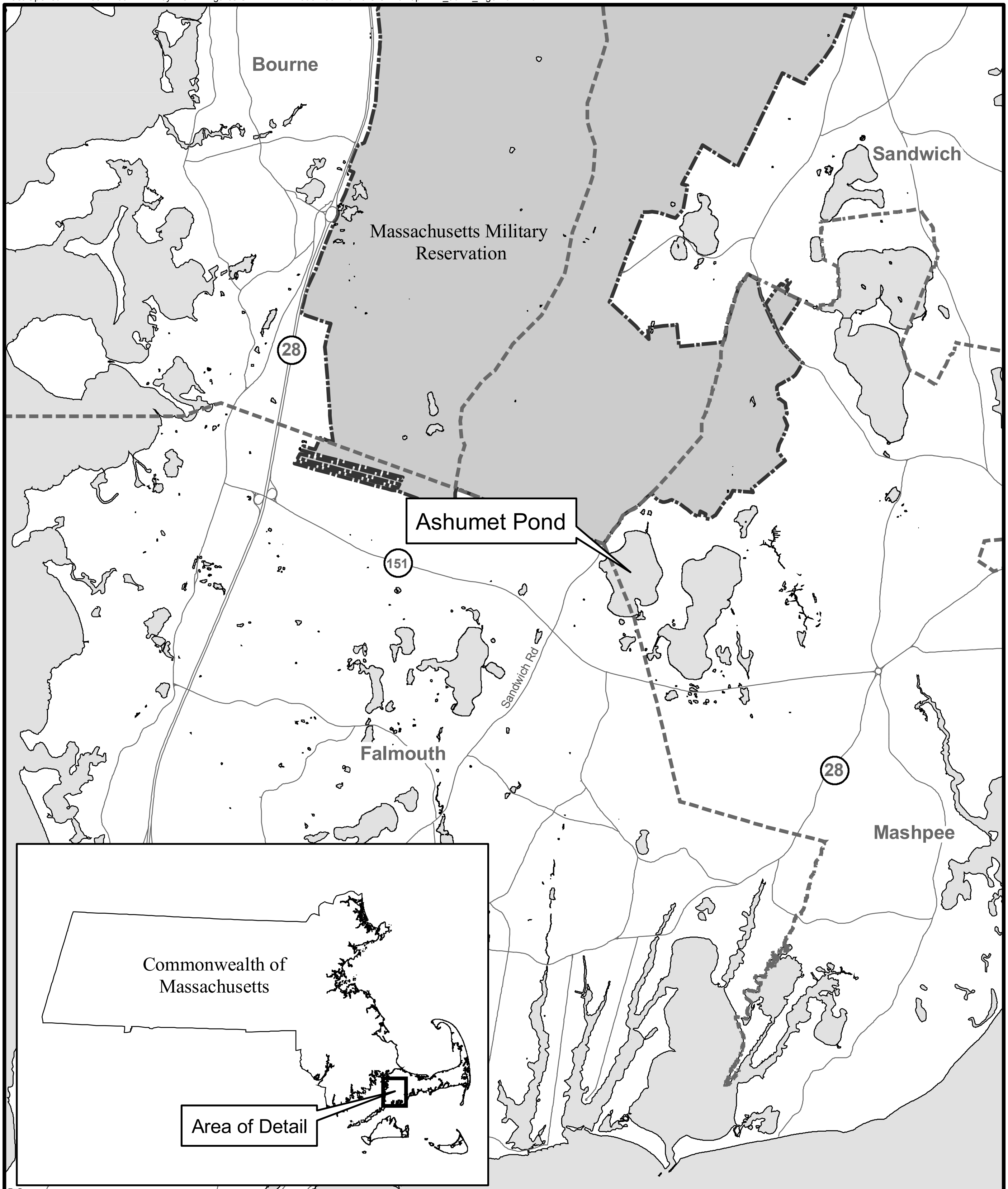
		Field Parameters					US Geological Survey National Water-Quality Laboratory			
USGS Station Name	USGS Location ID	Specific Conductance (µS/cm)	Temp (°C)	pH	Oxygen, dissolved (mg/L)	Field Phosphate (mg/L as P)	Nitrogen, Ammonia (mg/L as N)	Nitrogen, Nitrite plus Nitrate (mg/L as N)	Nitrogen, Nitrite (mg/L as N)	Phosphorus, Dissolved (mg/L)
MA-FSW 669-A01	01-20	155.0	24.7	---	0.03	0.78	0.030	<0.06	<0.002	0.66
MA-FSW 669-A01	01-20	149.0	21.8	---	0.43	1.03	0.018	<0.06	<0.002	0.60
MA-FSW 669-A02	02-20	191.0	25.0	---	0.160	0.24	0.012	<0.06	<0.002	0.19
MA-FSW 669-A02	02-20	187.0	22.3	---	0.400	0.39	0.016	<0.06	<0.002	0.31
MA-FSW 669-A03	02-90	102.0	26.9	---	0.170	1.37	0.496	<0.06	<0.002	1.25
MA-FSW 669-A03	02-90	100.0	21.5	---	0.810	0.99	0.447	<0.06	<0.002	0.97
MA-FSW 669-A04	03-20	192.0	28.2	---	0.055	0.05	0.014	<0.06	<0.002	0.03
MA-FSW 669-A04	03-20	191.0	25.6	---	0.870	0.00	0.018	<0.06	<0.002	E 0.01
MA-FSW 669-A05	03-90	161.0	27.8	---	0.070	0.24	0.433	<0.06	<0.002	0.17
MA-FSW 669-A05	03-90	146.0	26.5	---	0.230	0.54	0.349	<0.06	<0.002	0.49
MA-FSW 669-A06	04-00	138.0	28.2	---	0.555	0.00	0.043	<0.06	<0.002	--
MA-FSW 669-A06	04-00	173.0	23.60	---	0.09	0.02	0.241	<0.06	<0.002	<0.02
MA-FSW 669-A07	04-08	144.0	26.8	4.96	0.435	0.00	0.031	<0.06	<0.002	<0.02
MA-FSW 669-A07	04-08	176.0	21.7	5.73	0.635	0.05	0.231	<0.06	<0.002	E 0.01
MA-FSW 669-A08	04-16	182.0	26.4	5.53	0.160	0.13	0.146	<0.06	<0.002	<0.02
MA-FSW 669-A08	04-16	173.0	25.8	5.49	0.385	0.11	0.063	<0.06	<0.002	<0.02
MA-FSW 669-A08	04-16	182.0	21.8	5.77	0.18	0.10	0.243	<0.06	<0.002	<0.02
MA-FSW 669-A09	04-24	162.1	26.7	5.51	0.200	0.02	0.955	<0.06	<0.002	<0.02
MA-FSW 669-A09	04-24	142.4	24.9	5.60	0.155	0.02	2.200	<0.06	<0.002	<0.02
MA-FSW 669-A10	04-35	120.8	27.5	5.91	6.680	0.28	0.030	<0.06	<0.002	<0.02
MA-FSW 669-A10	04-35	139.1	22.8	6.12	0.345	0.42	0.192	<0.06	<0.002	--
MA-FSW 669-A11	05-08	176.6	23.2	6.18	0.200	1.32	0.063	0.45	0.002	1.03
MA-FSW 669-A11	05-08	198.0	16.7	6.21	0.620	1.11	0.127	0.90	<0.002	1.01
MA-FSW 669-A12	05-24	117.5	21.5	7.02	0.000	0.16	0.017	<0.06	<0.002	0.13
MA-FSW 669-A12	05-24	107.0	17.6	6.16	3.840	0.95	E 0.010	0.78	<0.002	0.85
MA-FSW 669-A13	05-46	121.9	23.8	5.65	3.790	0.42	E 0.010	0.86	<0.002	0.37
MA-FSW 669-A13	05-46	123.0	17.9	5.78	5.400	0.36	0.010	0.85	<0.002	0.25
MA-FSW 669-A14	06-00	196.3	22.2	6.10	0.060	1.37	0.092	<0.06	<0.002	1.18
MA-FSW 669-A14	06-00	196.0	18.4	6.16	0.075	1.34	0.096	<0.06	<0.002	1.14
MA-FSW 669-A14	06-00	197.0	16.9	6.18	0.290	1.14	0.097	<0.06	<0.002	1.07
MA-FSW 669-A15	06-08	128.5	24.7	7.21	0.040	0.15	0.252	<0.06	<0.002	0.09
MA-FSW 669-A15	06-08	163.3	19.9	8.02	0.225	0.07	0.395	<0.06	<0.002	0.04
MA-FSW 669-A15	06-08	173.5	17.3	6.47	0.485	0.75	0.385	0.67	<0.002	0.90
MA-FSW 669-A16	06-16	200.0	21.3	7.01	0.000	0.13	0.094	<0.06	<0.002	0.07
MA-FSW 669-A16	06-16	206.0	18.9	7.22	0.400	0.44	0.084	E 0.04	0.004	0.08
MA-FSW 669-A16	06-16	202.0	18.3	7.24	0.950	0.67	0.136	1.10	<0.002	0.59
MA-FSW 669-A17	06-24	143.0	23.6	7.33	0.010	0.16	0.384	<0.06	<0.002	0.10
MA-FSW 669-A17	06-24	156.3	20.4	7.38	0.030	0.11	0.413	<0.06	<0.002	0.05
MA-FSW 669-A17	06-24	160.5	17.2	6.57	0.200	0.80	0.452	1.19	<0.002	0.67
MA-FSW 669-A18	06-35	111.6	20.4	7.31	0.015	0.24	0.016	<0.06	<0.002	0.17
MA-FSW 669-A18	06-35	113.0	19.4	7.54	0.385	0.26	0.012	0.20	E 0.002	0.19
MA-FSW 669-A18	06-35	105.3	15.6	7.12	4.450	0.67	E 0.010	0.81	<0.002	0.64
MA-FSW 669-A19	06-46	80.4	21.8	6.46	4.220	0.52	0.010	0.71	<0.002	0.40
MA-FSW 669-A19	06-46	81.1	17.2	6.17	5.020	0.44	0.011	0.70	<0.002	0.36
MA-FSW 669-A20	06-57	81.1	19.6	6.47	4.640	0.31	E 0.009	0.81	<0.002	0.24
MA-FSW 669-A20	06-57	78.8	17.6	6.50	4.950	0.31	0.010	0.74	<0.002	0.21
MA-FSW 669-A21	07-00	170.0	20.1	6.04	0.210	1.65	0.121	<0.06	<0.002	1.32
MA-FSW 669-A21	07-00	178.0	17.7	6.06	0.500	1.55	0.110	<0.06	<0.002	1.31
MA-FSW 669-A21	07-00	174.7	14.2	6.06	0.490	1.45	0.101	<0.06	<0.002	1.30
MA-FSW 669-A22	07-08	172.0	22.8	7.01	0.000	0.03	0.583	<0.06	E 0.001	0.04
MA-FSW 669-A22	07-08	211.0	18.3	6.53	0.150	1.19	0.869	<0.06	<0.002	0.93
MA-FSW 669-A22	07-08	203.0	14.9	6.22	0.095	1.55	0.871	<0.06	<0.002	1.56
MA-FSW 669-A23	07-16	157.4	21.8	7.09	0.070	0.05	0.583	<0.06	<0.002	0.02
MA-FSW 669-A23	07-16	168.3	18.6	7.74	0.055	0.20	0.602	<0.06	<0.002	0.15
MA-FSW 669-A23	07-16	167.6	15.1	6.52	0.130	1.53	0.613	<0.06	<0.002	1.52
MA-FSW 669-A24	07-24	149.0	21.6	7.50	0.010	0.05	0.470	<0.06	<0.002	0.06
MA-FSW 669-A24	07-24	158.2	17.0	7.50	0.030	0.11	0.441	<0.06	<0.002	0.15
MA-FSW 669-A24	07-24	156.5	15.5	6.74	0.020	1.19	0.468	0.22	<0.002	1.24
MA-FSW 669-A25	07-35	99.4	20.1	8.09	0.010	0.16	E 0.010	<0.06	<0.002	0.09
MA-FSW 669-A25	07-35	95.7	17.5	7.49	1.970	0.24	E 0.010	0.66	0.006	0.19
MA-FSW 669-A25	07-35	91.8	15.5	6.70	1.840	0.44	0.010	1.20	<0.002	0.45
MA-FSW 669-A26	07-46	96.0	22.7	6.73	0.055	0.88	E 0.009	1.60	0.111	0.72
MA-FSW 669-A26	07-46	93.3	21.3	6.77	1.440	0.46	0.011	1.59	0.032	0.37
MA-FSW 669-A27	08-00	186.6	16.8	6.02	0.190	1.16	0.144	0.18	E 0.002	1.31
MA-FSW 669-A27	08-00	179.7	14.5	6.08	4.480	1.39	0.191	E 0.05	<0.002	1.27
MA-FSW 669-A27	08-00	175.7	13.3	6.08	0.250	1.27	0.215	<0.06	<0.002	1.26
MA-FSW 669-A28	08-08	235.0	19.4	7.10	0.000	0.00	0.754	<0.06	<0.002	0.03
MA-FSW 669-A28	08-08	235.0	17.2	6.71	3.680	0.00	0.991	<0.06	0.011	<0.02
MA-FSW 669-A28	08-08	228.0	14.1	6.30	---	1.13	1.010	<0.06	<0.002	1.15
MA-FSW 669-A29	08-16	180.5	20.8	7.40	0.000	0.16	0.918	<0.06	<0.002	0.15
MA-FSW 669-A29	08-16	207.0	16.5	7.23	2.120	0.07	1.080	<0.06	<0.002	0.08
MA-FSW 669-A29	08-16	188.4	16.5	6.46	0.640	1.47	0.940	<0.06	<0.002	1.37
MA-FSW 669-A30	08-24	163.5	21.5	7.33	0.000	0.36	0.795	<0.06	<0.002	0.34
MA-FSW 669-A30	08-24	163.7	19.1	7.57	0.350	0.23	0.783	<0.06	<0.002	0.18
MA-FSW 669-A30	08-24	169.1	15.9	6.62	2.840	1.44	0.781	<0.06	<0.002	1.50
MA-FSW 669-A31	08-35	107.5	21.3	8.21	0.045	0.24	0.019	0.23	0.008	0.09
MA-FSW 669-A31	08-35	106.0	19.1	7.20	5.000	0.18	0.014	<0.06	<0.002	0.18
MA-FSW 669-A31	08-35	96.4	16.2	6.67	5.260	0.65	E 0.010	0.79	<0.002	0.62
MA-FSW 669-A32	08-46	84.1	22.0	6.17	0.070	0.46	E 0.009	1.74	0.016	0.35
MA-FSW 669-A32	08-46	84.6	16.7	6.42	5.150	0.34	0.011	1.72	0.009	0.28
MA-FSW 669-A33	08-57	99.3	22.7	6.55	0.300	0.49	1.260	1.75	<0.002	0.47

		Field Parameters					US Geological Survey National Water-Quality Laboratory			
USGS Station Name	USGS Location ID	Specific Conductance (µS/cm)	Temp (°C)	pH	Oxygen, dissolved (mg/L)	Field Phosphate (mg/L as P)	Nitrogen, Ammonia (mg/L as N)	Nitrogen, Nitrite plus Nitrate (mg/L as N)	Nitrogen, Nitrite (mg/L as N)	Phosphorus, Dissolved (mg/L)
MA-FSW 669-A33	08-57	99.1	17.1	6.62	0.705	0.47	1.250	1.78	<0.002	0.41
MA-FSW 669-A34	09-00	196.4	20.8	6.97	0.020	0.05	E 0.652	<0.06	E 0.001	0.04
MA-FSW 669-A34	09-00	205.0	17.4	7.69	0.000	0.03	E 0.690	<0.06	E 0.002	0.04
MA-FSW 669-A34	09-00	195.8	14.0	6.99	0.110	1.40	0.717	<0.06	<0.002	1.38
MA-FSW 669-A35	09-08	199.0	21.4	7.11	0.000	0.11	0.798	<0.06	<0.002	0.07
MA-FSW 669-A35	09-08	207.0	18.1	7.95	0.265	0.16	0.841	<0.06	<0.002	0.14
MA-FSW 669-A35	09-08	206.0	15.2	6.90	0.290	1.60	0.896	<0.06	<0.002	1.44
MA-FSW 669-A36	09-16	168.5	20.3	7.51	0.000	0.24	0.901	<0.06	<0.002	0.37
MA-FSW 669-A36	09-16	161.0	18.2	8.12	0.100	0.41	0.905	<0.06	<0.002	0.36
MA-FSW 669-A36	09-16	160.4	17.6	7.04	0.585	1.68	0.832	<0.06	<0.002	1.69
MA-FSW 669-A37	09-24	109.5	20.1	7.89	0.110	0.39	0.368	<0.06	<0.002	0.40
MA-FSW 669-A37	09-24	111.2	19.0	7.60	2.210	0.51	0.179	0.28	0.005	0.32
MA-FSW 669-A37	09-24	109.0	17.3	6.97	0.560	1.03	0.073	1.23	<0.002	1.43
MA-FSW 669-A38	09-35	92.5	22.8	8.10	0.055	0.33	0.047	<0.06	<0.002	<0.02
MA-FSW 669-A38	09-35	89.5	22.1	6.85	2.850	0.38	E 0.010	0.95	0.039	0.48
MA-FSW 669-A38	09-35	83.8	19.4	6.29	2.410	0.62	E 0.005	0.92	<0.002	0.60
MA-FSW 669-A39	09-46	99.3	21.1	6.41	0.210	0.10	1.010	1.80	<0.002	0.62
MA-FSW 669-A39	09-46	95.8	15.5	6.24	0.235	0.72	1.620	1.83	<0.002	0.76
MA-FSW 669-A40	10-00	199.6	19.2	6.27	0.020	1.21	0.429	<0.06	<0.002	1.10
MA-FSW 669-A40	10-00	206.0	17.7	6.28	3.420	1.32	0.481	E 0.04	<0.002	1.11
MA-FSW 669-A40	10-00	207.0	14.6	6.30	0.545	1.27	0.512	<0.06	<0.002	1.17
MA-FSW 669-A41	10-08	184.2	19.8	7.16	0.000	0.08	E 0.567	<0.06	E 0.002	0.09
MA-FSW 669-A41	10-08	195.3	17.1	7.64	0.015	0.02	E 0.676	<0.06	E 0.002	0.04
MA-FSW 669-A41	10-08	200.0	15.9	7.28	6.090	0.15	E 0.696	<0.06	E 0.001	0.09
MA-FSW 669-A42	10-16	207.0	19.6	7.71	0.000	0.08	0.813	<0.06	<0.002	0.11
MA-FSW 669-A42	10-16	214.0	16.9	7.33	0.090	0.91	0.832	<0.06	<0.002	0.82
MA-FSW 669-A42	10-16	205.0	16.8	6.79	---	1.27	0.851	<0.06	<0.002	1.35
MA-FSW 669-A43	10-24	119.0	20.7	7.17	0.060	0.31	0.466	<0.06	<0.002	0.35
MA-FSW 669-A43	10-24	117.7	19.0	7.76	1.790	0.13	0.373	<0.06	<0.002	0.13
MA-FSW 669-A43	10-24	116.0	15.8	7.06	0.400	1.68	0.077	0.88	<0.002	1.50
MA-FSW 669-A44	10-35	97.0	18.6	7.39	0.000	0.03	E 0.014	<0.06	E 0.001	0.10
MA-FSW 669-A44	10-35	83.4	16.9	6.42	3.950	0.80	0.010	0.79	0.002	0.63
MA-FSW 669-A44	10-35	82.8	15.7	6.18	4.530	0.62	0.010	0.82	<0.002	0.67
MA-FSW 669-A45	10-46	93.9	21.4	6.02	0.070	0.49	E 0.007	1.88	0.042	0.43
MA-FSW 669-A45	10-46	90.5	19.1	5.93	0.120	0.54	<0.010	1.93	0.035	0.45
MA-FSW 669-A46	10-57	100.7	20.4	6.10	0.060	0.93	1.430	2.15	<0.002	0.76
MA-FSW 669-A46	10-57	100.7	17.3	6.18	0.225	0.91	1.650	2.17	E 0.001	0.81
MA-FSW 669-A46	10-57	101.5	15.9	6.35	0.545	0.93	1.780	2.20	<0.002	0.79
MA-FSW 669-A47	11-00	180.1	17.5	6.26	0.160	1.27	0.080	<0.06	E 0.001	0.91
MA-FSW 669-A47	11-00	189.6	16.3	6.30	0.495	1.06	0.051	<0.06	E 0.001	0.90
MA-FSW 669-A47	11-00	191.2	14.0	6.18	0.195	1.06	0.137	<0.06	E 0.001	0.90
MA-FSW 669-A48	11-08	199.3	18.4	7.06	0.000	0.57	0.740	<0.06	<0.002	0.15
MA-FSW 669-A48	11-08	199.4	16.2	7.05	6.100	1.47	0.756	<0.06	E 0.001	1.05
MA-FSW 669-A48	11-08	198.3	13.2	6.69	0.250	1.44	0.795	<0.06	E 0.002	1.50
MA-FSW 669-A49	11-16	170.9	21.2	5.89	0.025	0.23	0.763	<0.06	<0.002	0.17
MA-FSW 669-A49	11-16	175.4	17.6	7.89	3.530	0.13	0.773	<0.06	E 0.001	0.10
MA-FSW 669-A49	11-16	180.4	19.2	6.89	0.410	1.55	0.792	<0.06	E 0.001	1.43
MA-FSW 669-A50	11-24	138.3	20.9	7.87	0.020	0.23	0.479	<0.06	<0.002	0.18
MA-FSW 669-A50	11-24	138.2	17.7	8.38	0.180	0.23	0.466	<0.06	E 0.001	0.17
MA-FSW 669-A50	11-24	149.7	16.6	7.54	0.850	1.44	0.464	<0.06	<0.002	1.18
MA-FSW 669-A51	11-35	102.5	21.1	7.8	0.000	0.10	0.019	<0.06	<0.002	0.15
MA-FSW 669-A51	11-35	103.4	18.7	7.60	0.000	0.00	0.012	<0.06	E 0.001	0.05
MA-FSW 669-A51	11-35	95.6	17.2	6.61	6.000	0.52	E 0.006	0.64	<0.002	0.47
MA-FSW 669-A52	11-46	87.5	20.0	6.28	2.710	0.05	<0.010	0.43	E 0.002	0.07
MA-FSW 669-A52	11-46	86.5	15.7	6.03	5.420	0.34	E 0.007	0.78	<0.002	0.33
MA-FSW 669-A53	11-57	110.5	19.0	5.67	4.210	0.24	<0.010	1.06	<0.002	0.21
MA-FSW 669-A53	11-57	111.1	16.2	5.83	5.020	0.16	<0.010	1.00	<0.002	0.16
MA-FSW 669-A54	12-00	312.0	16.5	6.20	0.200	0.96	0.348	0.18	0.007	0.92
MA-FSW 669-A54	12-00	298.0	14.6	6.26	0.600	0.95	0.417	0.18	E 0.002	0.98
MA-FSW 669-A54	12-00	229.0	14.7	6.41	0.630	1.39	0.524	0.06	<0.002	1.28
MA-FSW 669-A55	12-08	196.8	19.3	6.58	0.005	0.21	0.722	<0.06	<0.002	0.16
MA-FSW 669-A55	12-08	191.9	16.7	6.82	0.145	1.44	0.703	<0.06	<0.002	1.40
MA-FSW 669-A55	12-08	188.2	15.8	7.01	0.345	1.29	0.708	<0.06	<0.002	1.51
MA-FSW 669-A56	12-16	217.0	20.2	7.59	0.000	0.29	0.242	<0.06	<0.002	0.16
MA-FSW 669-A56	12-16	236.0	21.6	7.80	0.035	0.10	0.217	<0.06	<0.002	0.05
MA-FSW 669-A56	12-16	228.0	16.5	6.98	0.295	0.88	0.207	E 0.05	<0.002	0.78
MA-FSW 669-A57	12-24	146.7	20.5	8.21	0.050	0.15	0.030	<0.06	<0.002	0.07
MA-FSW 669-A57	12-24	145.6	18.0	7.77	0.015	0.11	0.012	<0.06	<0.002	0.05
MA-FSW 669-A57	12-24	131.9	16.1	6.93	1.660	0.88	E 0.010	0.35	<0.002	0.73
MA-FSW 669-A58	12-35	115.3	22.1	7.42	0.010	0.11	E 0.009	<0.06	<0.002	0.06
MA-FSW 669-A58	12-35	114.3	18.5	7.93	0.005	0.10	<0.010	<0.06	0.010	0.06
MA-FSW 669-A58	12-35	110.1	16.4	6.45	5.640	0.47	E 0.007	0.70	<0.002	0.43
MA-FSW 669-A59	12-46	103.9	23.6	7.25	0.035	0.08	0.011	0.10	0.002	<0.02
MA-FSW 669-A59	12-46	96.3	16.7	6.23	5.490	0.39	E 0.008	0.75	<0.002	0.30
MA-FSW 669-A60	12-57	83.1	22.1	6.05	6.940	0.34	<0.010	0.77	<0.002	0.28
MA-FSW 669-A60	12-57	81.4	18.9	6.13	6.690	0.33	<0.010	0.77	<0.002	0.24
MA-FSW 669-A61	13-00	144.0	17.4	6.70	0.395	1.40	0.089	<0.06	<0.002	1.28
MA-FSW 669-A61	13-00	161.0	14.2	6.54	0.920	1.27	0.044	<0.06	<0.002	1.12
MA-FSW 669-A61	13-00	155.6	14.0	6.66	0.700	1.24	0.062	<0.06	<0.002	1.14
MA-FSW 669-A62	13-10	225.0	18.3	7.14	0.005	0.08	E 0.009	<0.06	<0.002	0.06
MA-FSW 669-A62	13-10	223.0	14.2	6.88	0.000	0.11	E 0.008	0.26	0.006	0.12
MA-FSW 669-A62	13-10	208.0	14.2	6.16	3.500	0.65	<0.010	0.64	<0.002	0.62
MA-FSW 669-A63	13-16	183.4	19.2	7.19	0.000	0.02	E 0.010	E 0.06	E 0.002	0.03
MA-FSW 669-A63	13-16	174.2	16.2	6.39	2.900	0.05	E 0.005	0.41	0.003	0.12
MA-FSW 669-A63	13-16	161.9	14.4	5.81	5.990	0.21	E 0.006	0.50	<0.002	0.39

		Field Parameters					US Geological Survey National Water-Quality Laboratory			
USGS Station Name	**USGS Location ID**	**Specific Conductance (µS/cm)**	**Temp (°C)**	**pH**	**Oxygen, dissolved (mg/L)**	**Field Phosphate (mg/L as P)**	**Nitrogen, Ammonia (mg/L as N)**	**Nitrogen, Nitrite plus Nitrate (mg/L as N)**	**Nitrogen, Nitrite (mg/L as N)**	**Phosphorus, Dissolved (mg/L)**
MA-FSW 669-A64	13-24	130.7	18.3	6.75	0.000	0.13	0.011	<0.06	<0.002	0.10
MA-FSW 669-A64	13-24	128.8	16.4	7.64	0.145	0.03	0.011	<0.06	<0.002	0.05
MA-FSW 669-A64	13-24	122.4	15.8	6.54	6.610	0.21	E 0.006	0.51	<0.002	0.24
MA-FSW 669-A65	13-35	92.8	19.1	7.34	0.000	0.00	0.010	<0.06	<0.002	E 0.01
MA-FSW 669-A65	13-35	104.5	16.7	7.19	0.875	0.00	<0.010	0.30	0.003	<0.02
MA-FSW 669-A65	13-35	82.0	15.9	6.25	7.140	0.18	<0.010	0.72	<0.002	0.35
MA-FSW 669-A66	13-46	81.4	17.9	6.20	2.290	0.15	0.014	0.24	<0.002	0.14
MA-FSW 669-A66	13-46	92.0	18.2	6.18	6.620	0.16	<0.010	0.53	<0.002	0.17
MA-FSW 669-A67	14-00	155.5	16.4	6.28	0.355	0.88	<0.010	0.22	E 0.002	0.83
MA-FSW 669-A67	14-00	151.2	16.6	6.31	2.320	0.99	E 0.006	0.32	<0.002	0.86
MA-FSW 669-A67	14-00	160.6	15.0	6.18	1.670	1.08	<0.010	0.46	<0.002	0.84
MA-FSW 669-A68	14-11	155.1	19.4	7.19	0.000	0.03	<0.010	<0.06	<0.002	0.04
MA-FSW 669-A68	14-11	162.3	16.2	7.45	0.000	0.00	E 0.006	E 0.04	0.011	<0.02
MA-FSW 669-A68	14-11	139.8	14.9	6.06	6.460	0.39	<0.010	0.55	<0.002	0.38
MA-FSW 669-A69	14-16	127.1	18.8	6.60	0.005	0.08	0.017	<0.06	E 0.001	0.03
MA-FSW 669-A69	14-16	128.8	17.0	6.60	---	0.03	0.013	0.41	0.009	<0.02
MA-FSW 669-A69	14-16	106.7	15.1	5.93	6.910	0.28	E 0.006	0.61	<0.002	0.26
MA-FSW 669-A70	14-24	84.3	19.9	6.36	2.370	0.02	E 0.009	0.25	<0.002	<0.02
MA-FSW 669-A70	14-24	103.2	18.4	5.92	5.660	0.21	0.011	0.54	0.004	0.18
MA-FSW 669-A70	14-24	82.7	17.1	5.80	7.440	0.26	<0.010	0.55	<0.002	0.34
MA-FSW 669-A71	14-35	130.9	19.6	6.79	0.030	0.02	0.022	E 0.03	0.004	0.02
MA-FSW 669-A71	14-35	114.2	17.7	6.06	6.210	0.03	E 0.009	0.53	0.002	E 0.02
MA-FSW 669-A71	14-35	101.3	16.1	5.84	8.380	0.16	<0.010	0.55	<0.002	0.11
MA-FSW 669-A72	14-46	100.0	21.2	5.51	7.620	0.10	<0.010	0.53	<0.002	0.11
MA-FSW 669-A72	14-46	99.6	18.4	5.66	8.370	0.08	E 0.006	0.55	<0.002	0.09
MA-FSW 669-A72	14-46	99.0	16.5	5.57	8.990	0.10	E 0.005	0.55	<0.002	0.09
MA-FSW 669-A73	14-57	106.2	21.4	6.19	8.510	0.07	E 0.006	0.48	<0.002	0.04
MA-FSW 669-A73	14-57	108.0	17.1	6.27	8.060	0.05	E 0.007	0.48	<0.002	0.02
MA-FSW 669-A74	15-00	142.8	17.0	6.02	7.010	0.49	<0.010	0.49	<0.002	0.41
MA-FSW 669-A74	15-00	162.1	15.7	5.95	7.690	0.44	E 0.007	0.58	<0.002	0.36
MA-FSW 669-A75	15-16	79.9	17.6	5.39	7.880	0.31	<0.010	0.56	<0.002	0.26
MA-FSW 669-A75	15-16	85.1	16.6	5.77	8.040	0.15	<0.010	0.54	<0.002	0.36
MA-FSW 669-A76	15-35	115.2	18.0	6.10	9.090	0.28	<0.010	0.52	<0.002	0.19
MA-FSW 669-A76	15-35	108.6	18.5	6.45	8.500	0.20	<0.010	0.49	<0.002	0.14

Additional Push Points Near the Shoreline - Field Measurements Only

---	04-(-04)	164.0	---	---	---	0.15	---	---	---	---
---	04-(-08)	125.0	---	---	---	0.03	---	---	---	---
---	04-(-12)	80.0	---	---	---	0.00	---	---	---	---
---	05-(-04)	227.0	---	---	---	1.48	---	---	---	---
---	05-(-08)	95.3	---	---	---	0.02	---	---	---	---
---	05-(-12)	67.1	---	---	---	0.02	---	---	---	---
---	06-(-04)	197.9	---	---	---	1.24	---	---	---	---
---	06-(-08)	190.2	---	---	---	1.53	---	---	---	---
---	06-(-12)	71.9	---	---	---	0.03	---	---	---	---
---	07-(-04)	178.3	---	---	---	1.24	---	---	---	---
---	07-(-08)	195.4	---	---	---	1.47	---	---	---	---
---	07-(-12)	63.3	---	---	---	0.00	---	---	---	---
---	08-(-04)	223.0	---	---	---	0.05	---	---	---	---
---	08-(-08)	232.0	---	---	---	1.50	---	---	---	---
---	08-(-12)	63.5	18.1	---	---	0.02	---	---	---	---
---	09-(-04)	306.0	18.4	---	---	0.05	---	---	---	---
---	09-(-08)	197.6	20.0	---	---	1.09	---	---	---	---
---	09-(-12)	108.7	15.5	---	---	0.07	---	---	---	---
---	10-(-04)	210.0	18.7	---	---	0.13	---	---	---	---
---	10-(-08)	189.5	19.7	---	---	1.16	---	---	---	---
---	10-(-12)	133.1	16.0	---	---	0.70	---	---	---	---
---	11-(-04)	201.0	16.6	---	---	0.39	---	---	---	---
---	11-(-08)	162.2	17.6	---	---	1.04	---	---	---	---
---	11-(-12)	141.1	14.0	---	---	0.11	---	---	---	---
---	12-(-04)	261.0	16.2	---	---	1.17	---	---	---	---
---	12-(-08)	118.3	14.7	---	---	1.06	---	---	---	---
---	12-(-12)	78.4	16.7	---	---	0.15	---	---	---	---
---	13-(-04)	142.4	16.9	---	---	0.70	---	---	---	---
---	13-(-08)	94.9	16.9	---	---	0.15	---	---	---	---
---	13-(-12)	107.7	14.5	---	---	0.59	---	---	---	---
---	14-(-04)	202.0	18.7	---	---	0.11	---	---	---	---
---	14-(-08)	139.4	15.1	---	---	1.40	---	---	---	---
---	14-(-12)	118.1	14.4	---	---	0.72	---	---	---	---
---	15-(-04)	161.8	16.3	---	---	0.67	---	---	---	---
---	15-(-08)	141.9	14.9	---	---	1.08	---	---	---	---
---	15-(-12)	110.6	17.1	---	---	0.02	---	---	---	---



Data Source: AFCEE, MMR-AFCEE Data Warehouse

Legend

Town Boundary

Massachusetts Military Reservation Boundary

N

0 0.7 1.4 Miles

FIGURE 1-1

LOCATION OF ASHUMET POND

AFCEE - Massachusetts Military Reservation

Final Ashumet Pond 2006 Phosphorus Barrier Technical Memorandum

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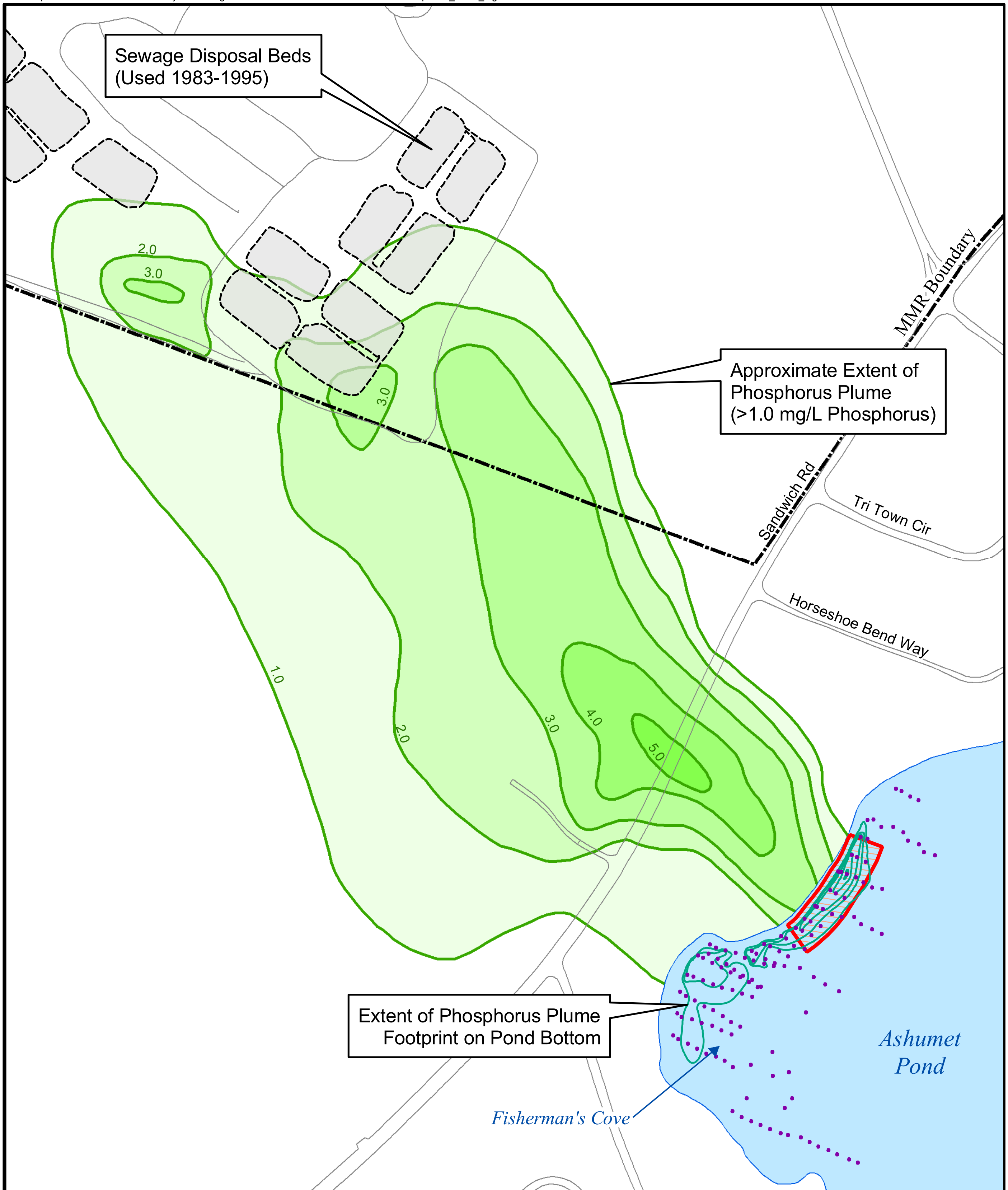

Legend

- Abandoned Sewage Treatment Beds
- Pond (Based on April 1997 Aerial Photography)
- Geochemical Barrier
- Phosphorus Isopleths (mg/L) from USGS (1999 Data)
- MMR Boundary
- USGS Drive Points Installed for AFCEE (1999)

Phosphorus Plume Concentrations from USGS (1999 Data)

- 1.0 mg/L
- 2.0 mg/L
- 3.0 mg/L
- 4.0 mg/L
- 5.0 mg/L

N

0 170 340 Feet

FIGURE 1-2

PHOSPHORUS PLUME AND DISCHARGE AREA IN ASHUMET POND (1999)

AFCEE - Massachusetts Military Reservation

Final Ashumet Pond 2006 Phosphorus Barrier Technical Memorandum

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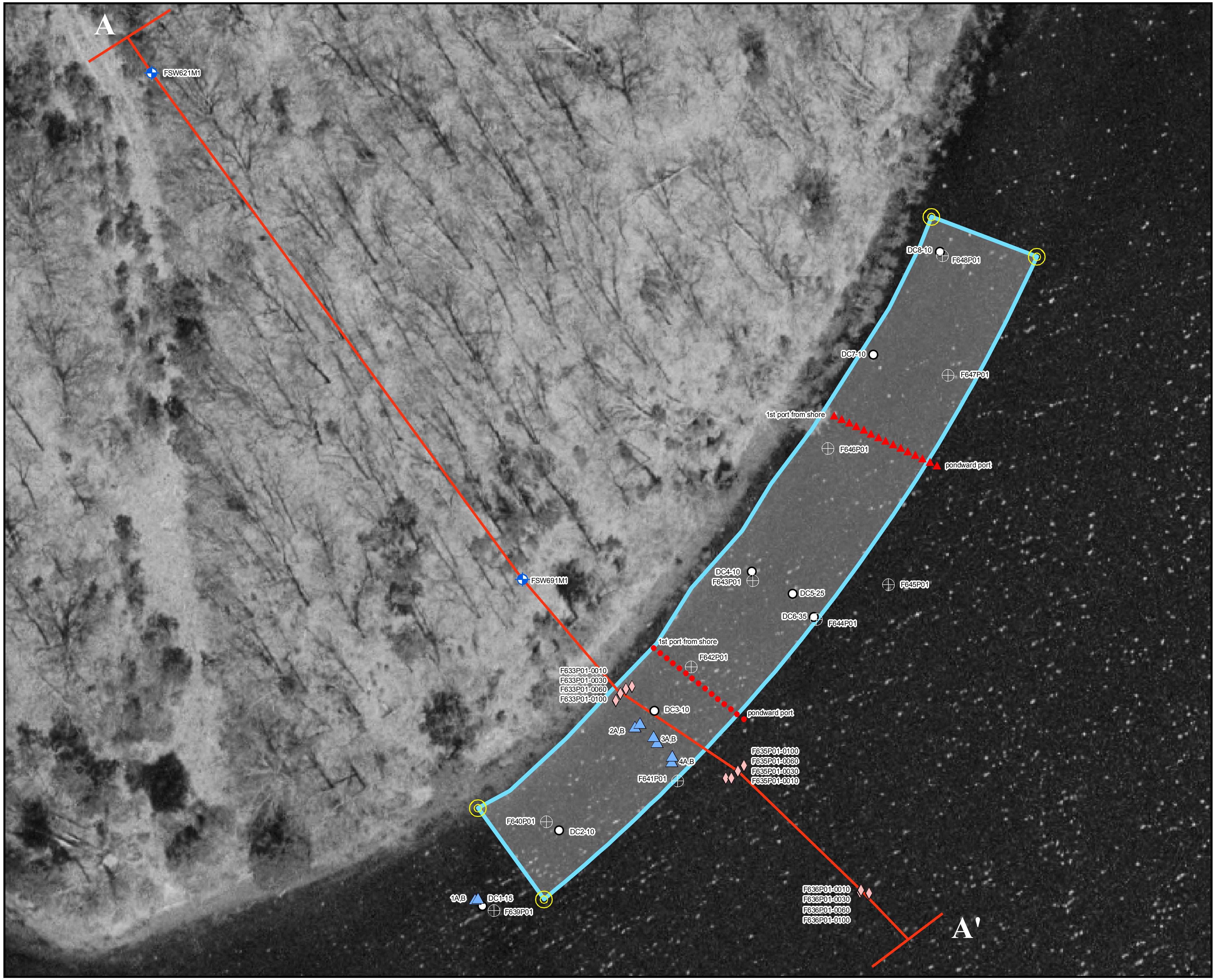

Legend

- Ashumet Pond Barrier
- Transect Line (A-A')
- Diffusion Chamber
- Northern Horizontal Multiport Sampler
- Southern Horizontal Multiport Sampler
- Pond-Bottom Piezometer
- Vertical Multilevel Sampler
- Stake-out Points of Barrier
- Monitoring Well
- USGS Seep Sample

N

0 18 36
Feet

Data Source: AFCEE, January 2007, MMR-AFCEE
Data Warehouse. 1997 Aerial Photography.

FIGURE 2-1

USGS PERMANENT BARRIER SAMPLING LOCATIONS

AFCEE - Massachusetts Military Reservation
Final Ashumet Pond 2006 Phosphorus Barrier Technical Memorandum

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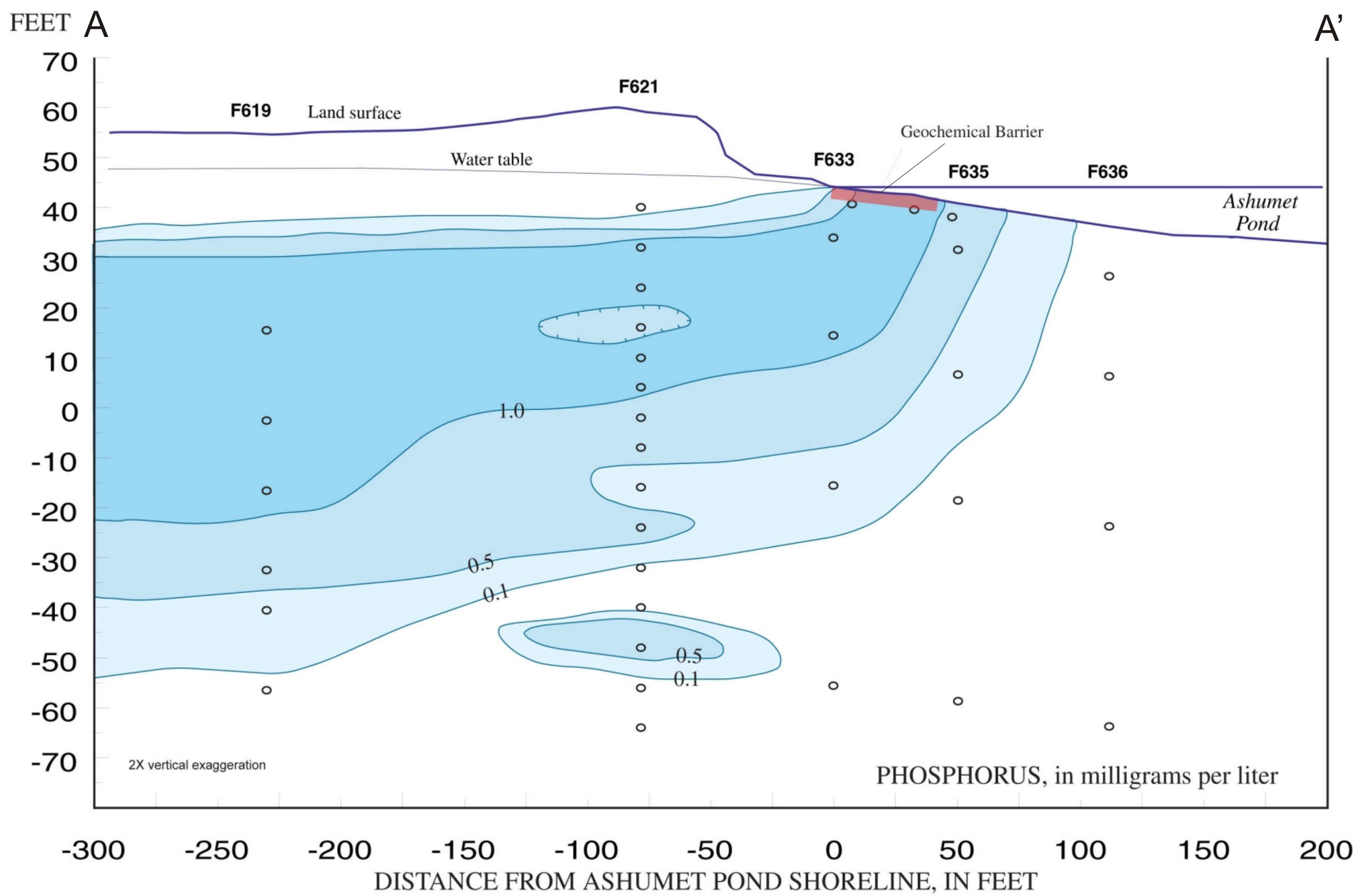

Data Source: USGS, August 2006

Legend

- > 1.0
- 0.5 - 1.0
- 0.1 - 0.5

Vertical Extent of Phosphorus in Pond-Bottom Ground Water (2006)
Concentrations in Milligrams Per Liter as P. Interval Varies

FIGURE 2-2

DISSOLVED PHOSPHORUS CONCENTRATIONS ALONG CROSS-SECTION A-A'

AFCEE - Massachusetts Military Reservation
Final Ashumet Pond 2006 Phosphorus Barrier Technical Memorandum

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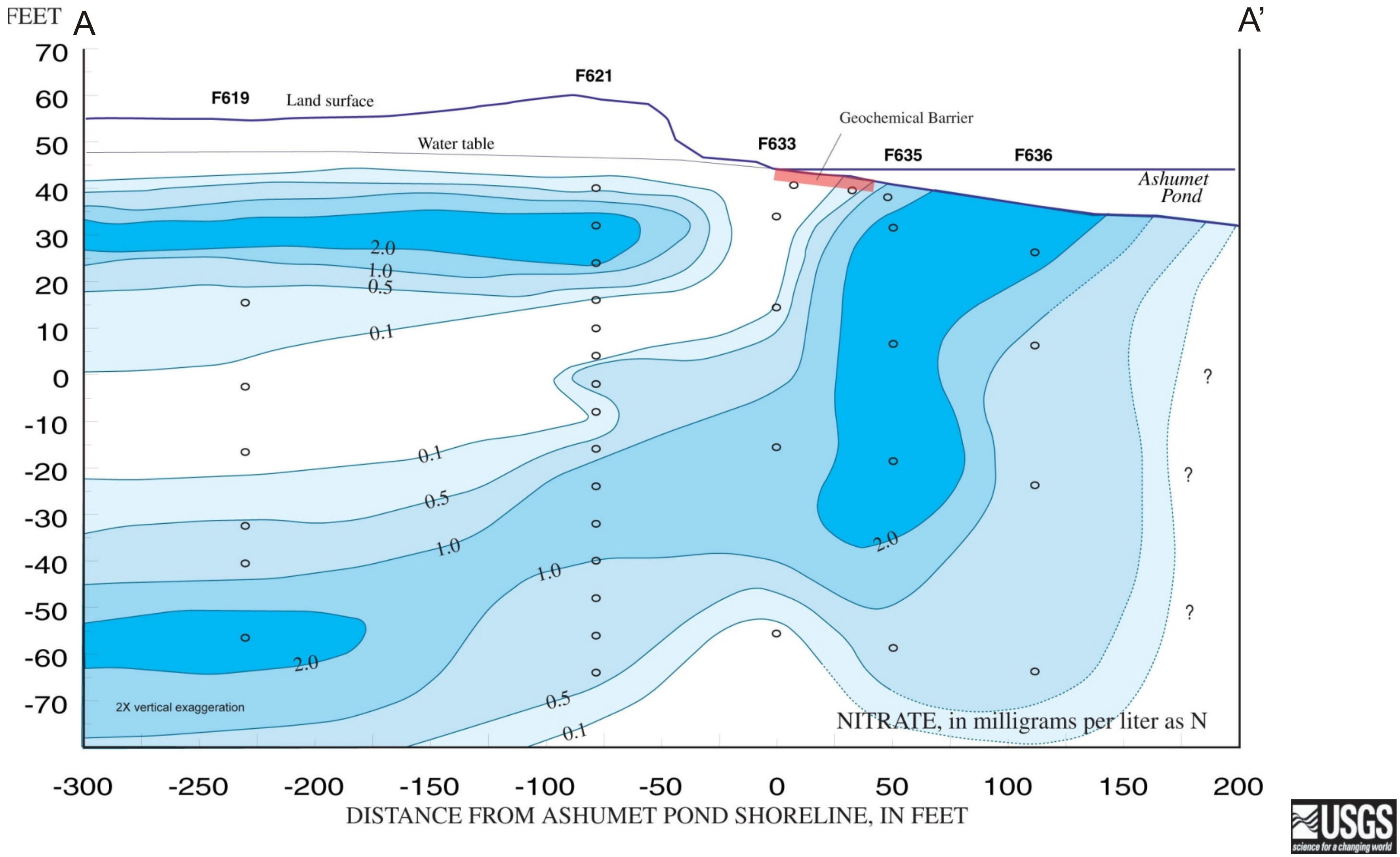

Data Source: USGS, August 2006

Legend

- > 2.0
- 1.0 - 2.0
- 0.5 - 1.0
- 0.1 - 0.5

Vertical Extent of Nitrate in Pond-Bottom Ground Water (2006)
Concentrations in Milligrams Per Liter as N. Interval Varies

FIGURE 2-3

NITRATE CONCENTRATIONS ALONG CROSS-SECTION A-A'

AFCEE - Massachusetts Military Reservation

Final Ashumet Pond 2006 Phosphorus Barrier Technical Memorandum

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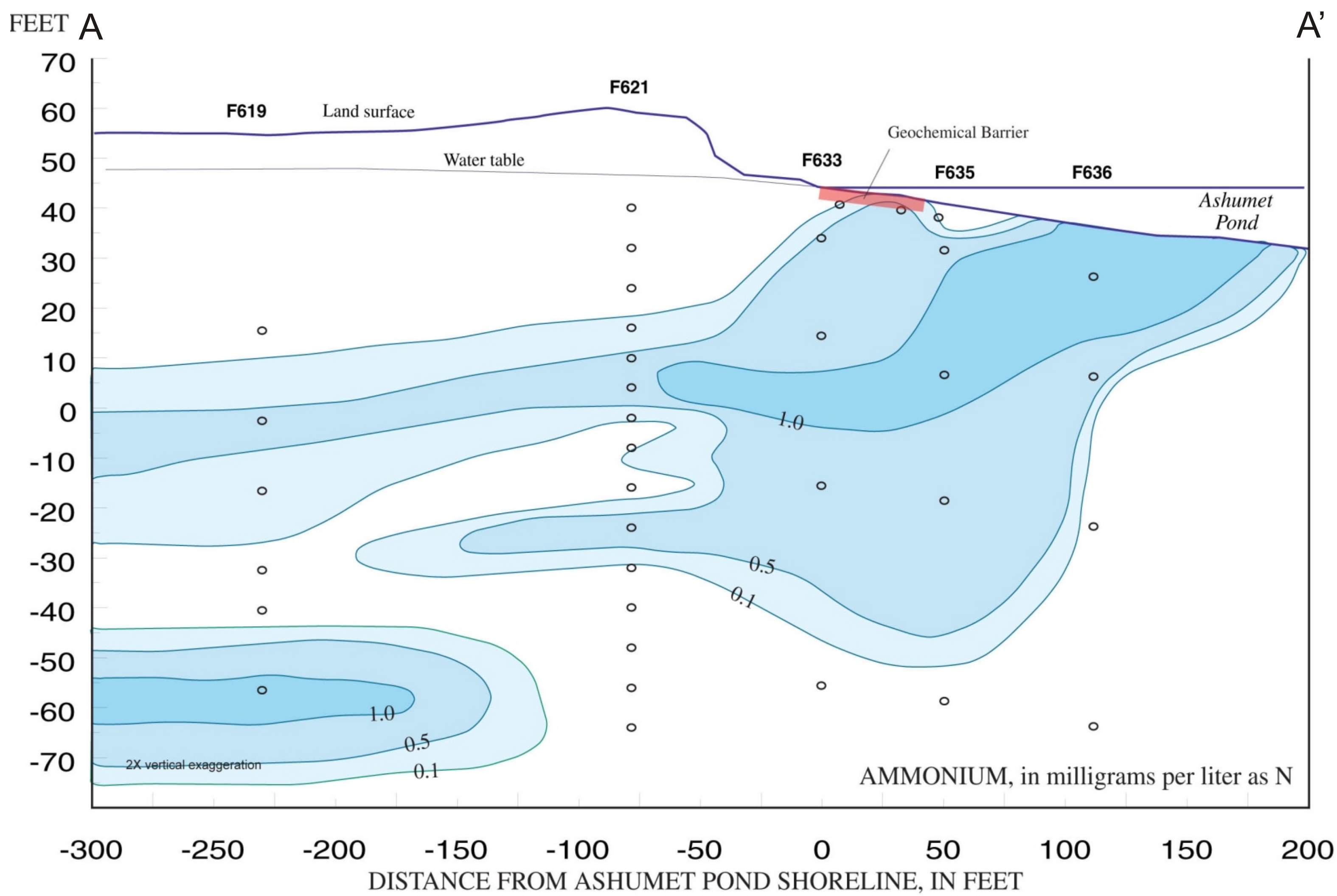
Y:\Figures\SPEIM\APB\2006\TechMemo\Corel\APR_06TM_Fig02-04.cdr 02/05/07 mcb



Legend

> 1.0

0.5 - 1.0

0.1 - 0.5

Vertical Extent of Ammonium in Pond-Bottom Ground Water (2006)
Concentrations in Milligrams Per Liter as N. Interval Varies

Data Source: USGS, August 2006

FIGURE 2-4

AMMONIUM CONCENTRATIONS ALONG CROSS-SECTION A-A'

AFCEE - Massachusetts Military Reservation

Final Ashumet Pond 2006 Phosphorus Barrier Technical Memorandum

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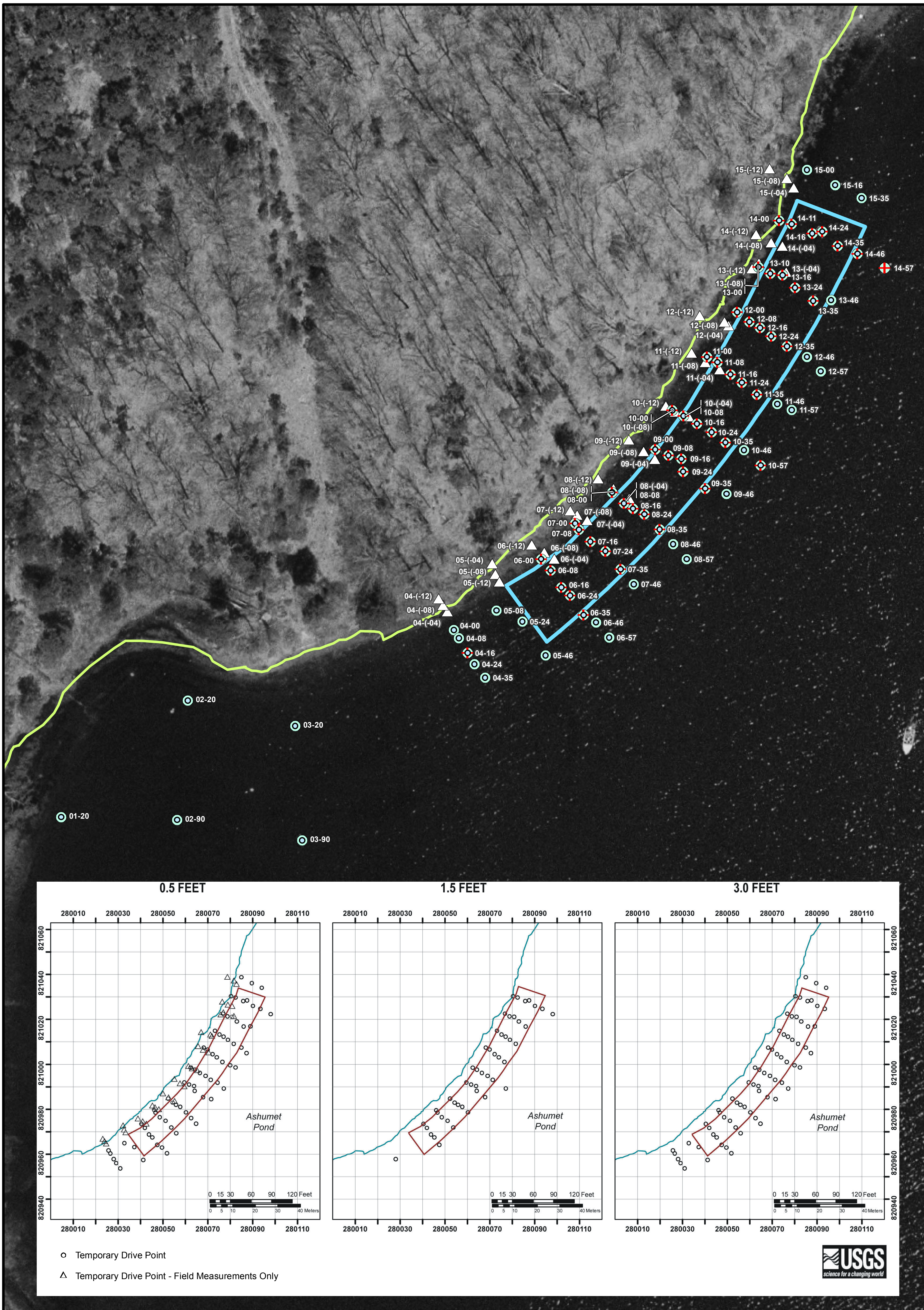

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Legend

Shoreline (Delineated by USGS July, 2006)

*Barrier Boundary

04-08 USGS Location ID (See Appendix A)

*Barrier boundary delineated by ECC; shoreward edge refined based on GPS readings.

USGS Temporary Drive Point Sampling Locations by Depth (ft):

- 0.5 and 1.5
- 0.5 and 3.0
- 0.5, 1.5 and 3.0
- 0.5 (Field Measurements Only)

Data Source: USGS 2006; 1997 Aerial Photography from AFCEE

N

0 25 50 Feet

FIGURE 2-5

USGS TEMPORARY DRIVE POINT LOCATIONS

AFCEE - Massachusetts Military Reservation

Final Ashumet Pond 2006 Phosphorus Barrier Technical Memorandum

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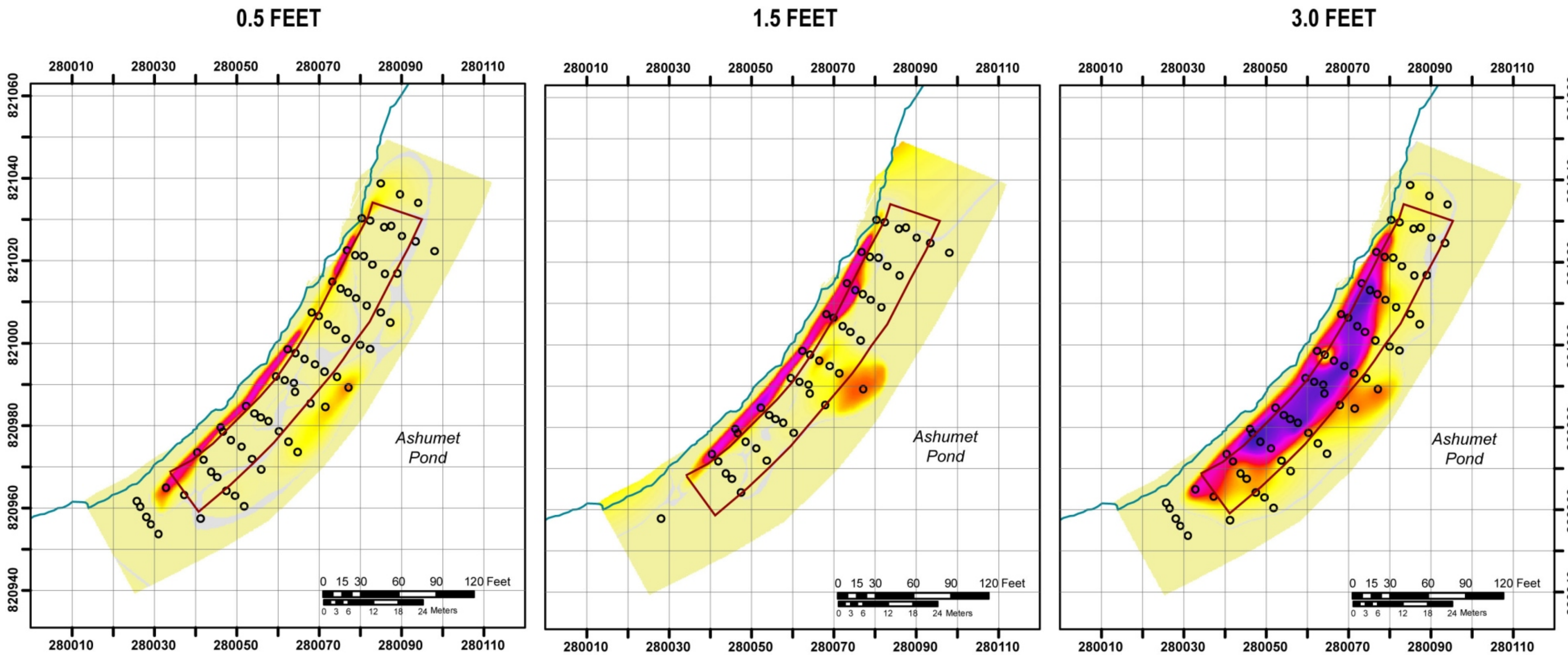
Depth Below Pond Bottom



USGS science for a changing world

Data Source: USGS, August 2006

Legend

○ Temporary Drive Point

Dissolved Phosphorus In Milligrams Per Liter As P

1.70

0.9

0.1

< 0.1

Note: Shoreline position determined by GPS on 7/28/06 by the US Geological Survey. Extent of the geochemical barrier determined using GPS by CH2M Hill in October 2006. State plane coordinates in NAD83 (meters).

FIGURE 2-6

CHANGES IN PHOSPHORUS CONCENTRATIONS WITH DEPTH IN THE GEOCHEMICAL BARRIER

AFCEE - Massachusetts Military Reservation

Final Ashumet Pond 2006 Phosphorus Barrier Technical Memorandum

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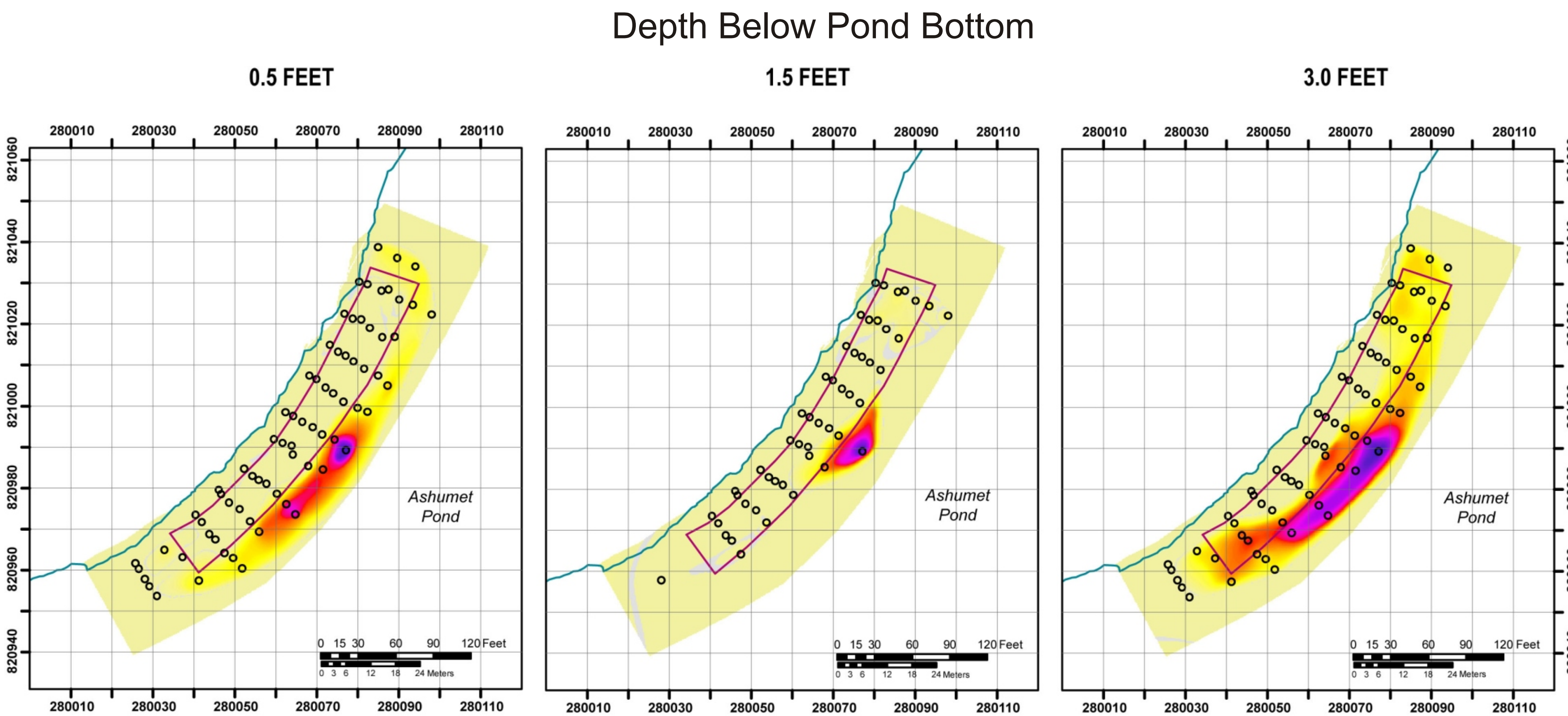

Data Source: USGS, August 2006

Legend

○ Temporary Drive Point

Dissolved Nitrate
In Milligrams Per Liter
As N

2.25
1.20
0.1

< 0.1

Note: Shoreline position determined by GPS on 7/28/06 by the US Geological Survey. Extent of the geochemical barrier determined using GPS by CH2M Hill in October 2006. State plane coordinates in NAD83 (meters).

FIGURE 2-7

CHANGES IN NITRATE CONCENTRATIONS WITH DEPTH IN THE GEOCHEMICAL BARRIER

AFCEE - Massachusetts Military Reservation

Final Ashumet Pond 2006 Phosphorus Barrier Technical Memorandum

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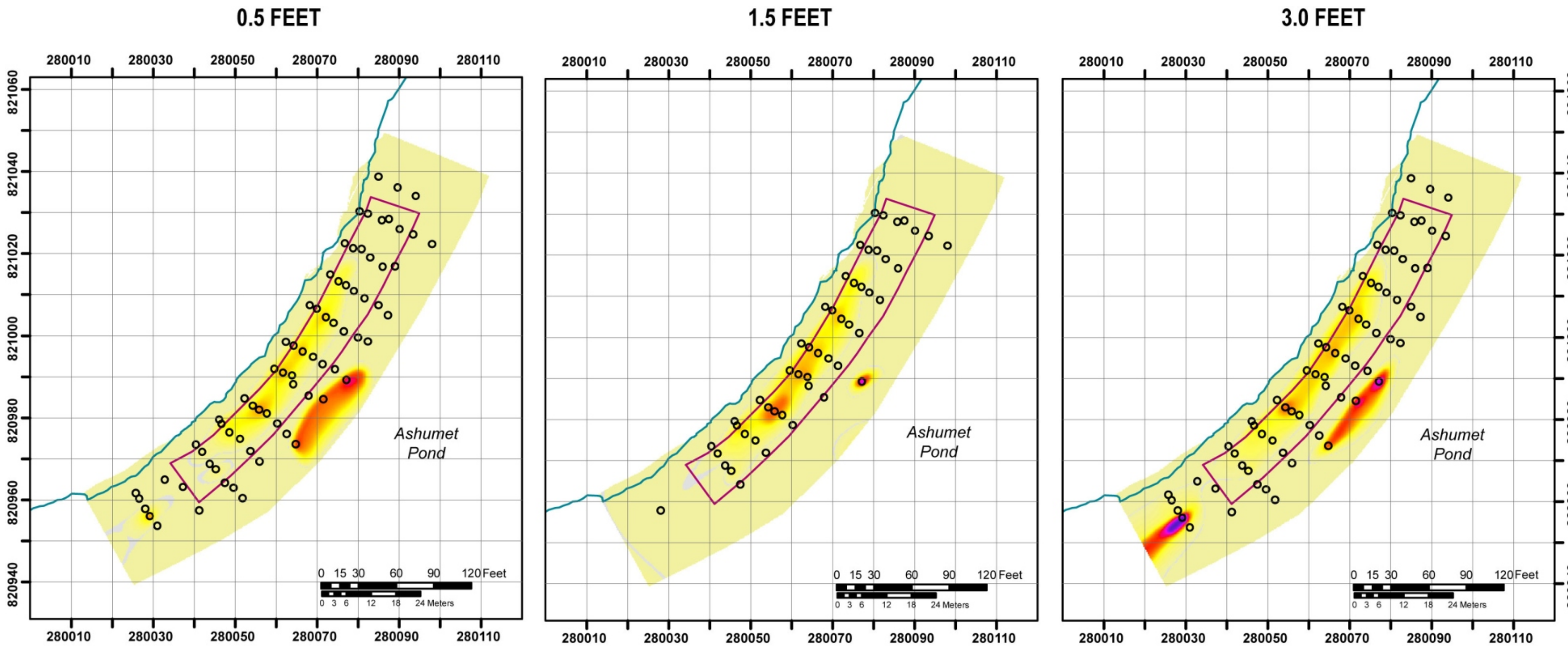
Depth Below Pond Bottom



Data Source: USGS, August 2006

Legend

○ Temporary Drive Point

Dissolved Ammonium In Milligrams Per Liter As N

2.25

1.20

0.1

< 0.1

Note: Shoreline position determined by GPS on 7/28/06 by the US Geological Survey. Extent of the geochemical barrier determined using GPS by CH2M Hill in October 2006. State plane coordinates in NAD83 (meters).

FIGURE 2-8

CHANGES IN AMMONIUM CONCENTRATIONS WITH DEPTH IN THE GEOCHEMICAL BARRIER

AFCEE - Massachusetts Military Reservation

Final Ashumet Pond 2006 Phosphorus Barrier Technical Memorandum

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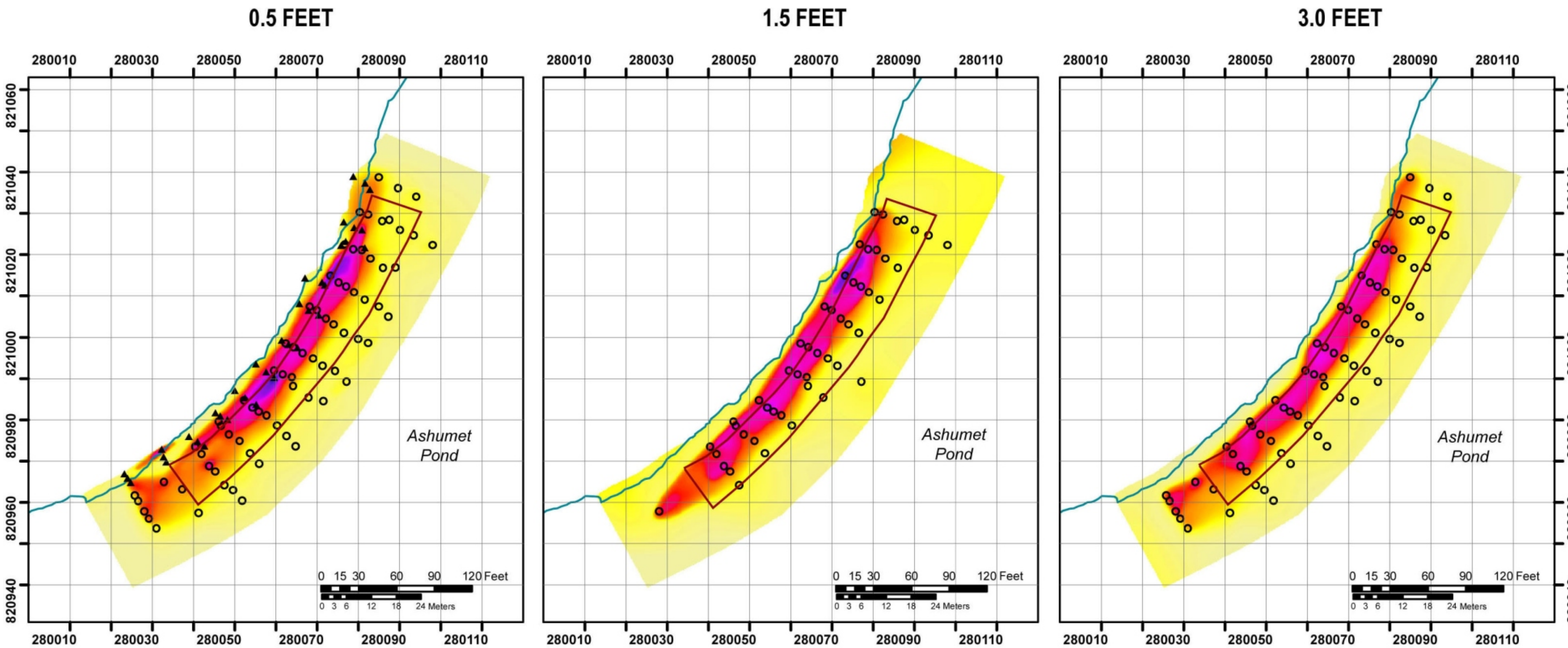
Depth Below Pond Bottom



USGS science for a changing world

Legend

○ Temporary Drive Point

△ Temporary Push Point - Field Measurements Only

Note: Shoreline position determined by GPS on 7/28/06 by the US Geological Survey. Extent of the geochemical barrier determined using GPS by CH2M Hill in October 2006. State plane coordinates in NAD83 (meters).

Specific Conductance In Microsiemens Per Centimeter

300

175

50

Data Source: USGS, August 2006

FIGURE 2-9

CHANGES IN SPECIFIC CONDUCTANCE WITH DEPTH IN THE GEOCHEMICAL BARRIER

AFCEE - Massachusetts Military Reservation

Final Ashumet Pond 2006 Phosphorus Barrier Technical Memorandum

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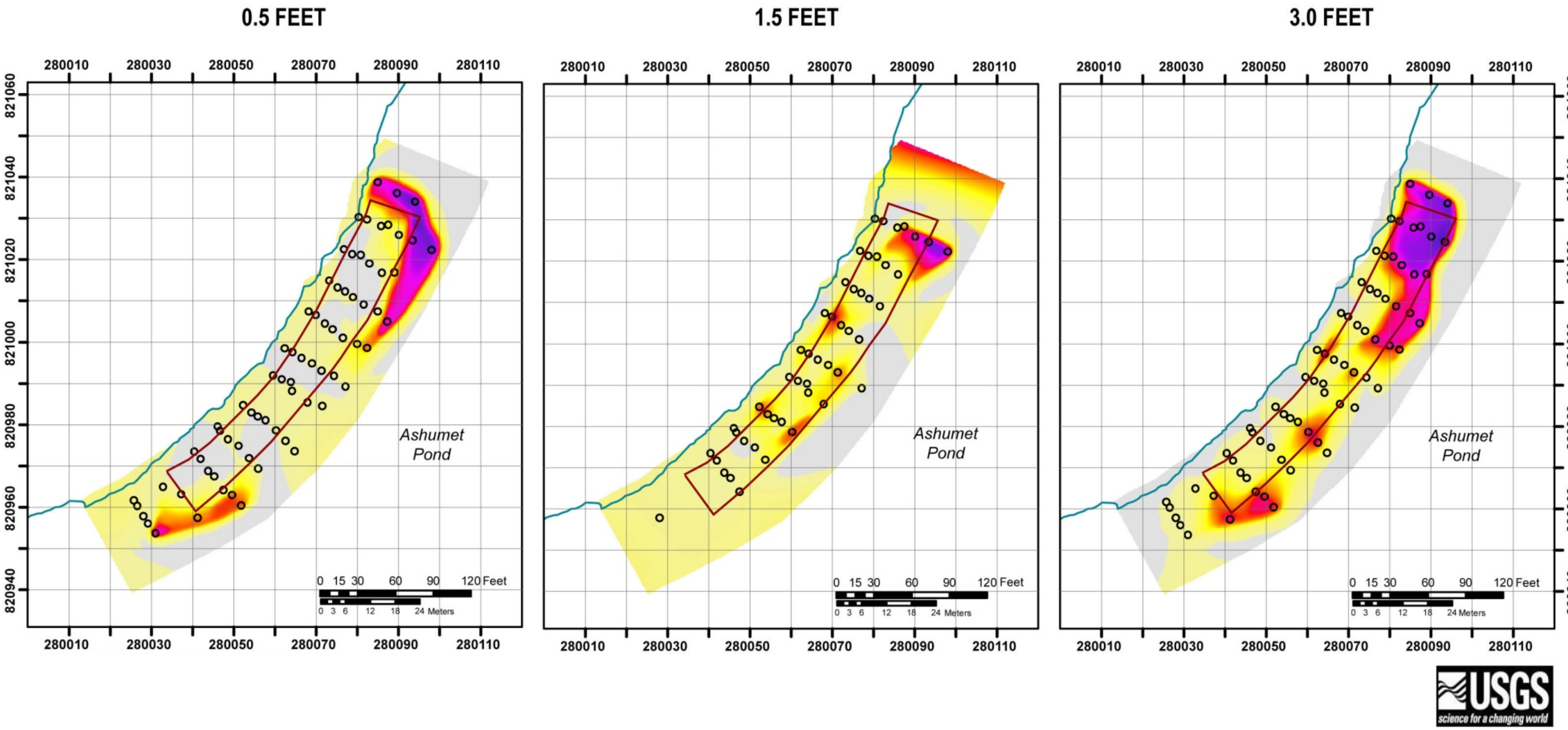
Depth Below Pond Bottom



Legend

○ Temporary Drive Point

Dissolved Oxygen In Milligrams Per Liter

10

5

0.1

< 0.1

Data Source: USGS, August 2006

Note: Shoreline position determined by GPS on 7/28/06 by the US Geological Survey. Extent of the geochemical barrier determined using GPS by CH2M Hill in October 2006. State plane coordinates in NAD83 (meters).

FIGURE 2-10

CHANGES IN DISSOLVED OXYGEN CONCENTRATIONS WITH DEPTH IN THE GEOCHEMICAL BARRIER

AFCEE - Massachusetts Military Reservation

Final Ashumet Pond 2006 Phosphorus Barrier Technical Memorandum

CH2MHILL

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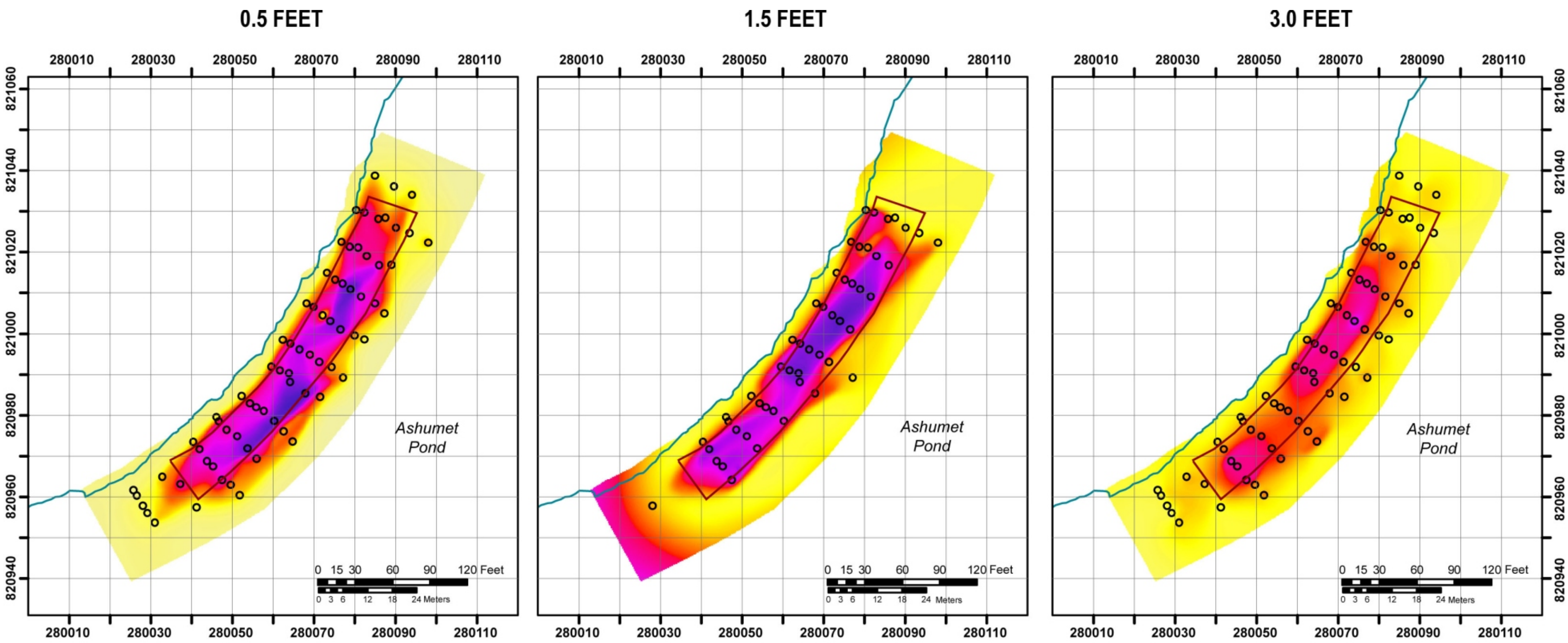
Depth Below Pond Bottom



Data Source: USGS, August 2006

Legend

○ Temporary Drive Point

PH
Standard Units

8.5
6.8
5.0

Note: Shoreline position determined by GPS on 7/28/06 by the US Geological Survey. Extent of the geochemical barrier determined using GPS by CH2M Hill in October 2006. State plane coordinates in NAD83 (meters).

FIGURE 2-11

CHANGES IN pH WITH DEPTH IN THE GEOCHEMICAL BARRIER

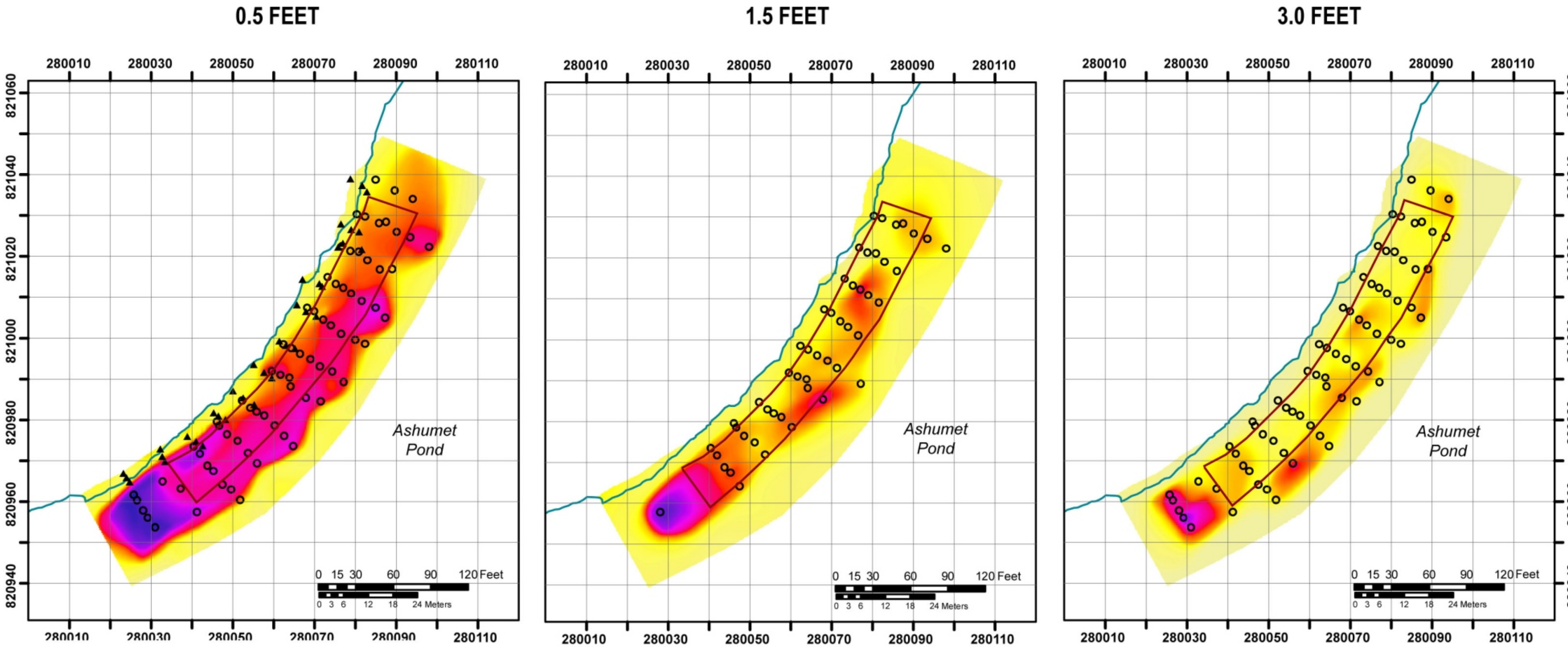
AFCEE - Massachusetts Military Reservation

Final Ashumet Pond 2006 Phosphorus Barrier Technical Memorandum

CH2MHILL

Y:\Figures\SPEIM\APB\2006\TechMemo\Corel\APR_06TM_Fig02-12.cdr 02/28/07 mcb

Depth Below Pond Bottom



Data Source: USGS, August 2006

Legend

○ Temporary Drive Point

▲ Temporary Drive Point - Field Measurements Only

Temperature °C

28

21

13

Note: Shoreline position determined by GPS on 7/28/06 by the US Geological Survey. Extent of the geochemical barrier determined using GPS by CH2M Hill in October 2006. State plane coordinates in NAD83 (meters).

FIGURE 2-12

CHANGES IN GROUNDWATER TEMPERATURE WITH DEPTH IN THE GEOCHEMICAL BARRIER

AFCEE - Massachusetts Military Reservation

Final Ashumet Pond 2006 Phosphorus Barrier Technical Memorandum

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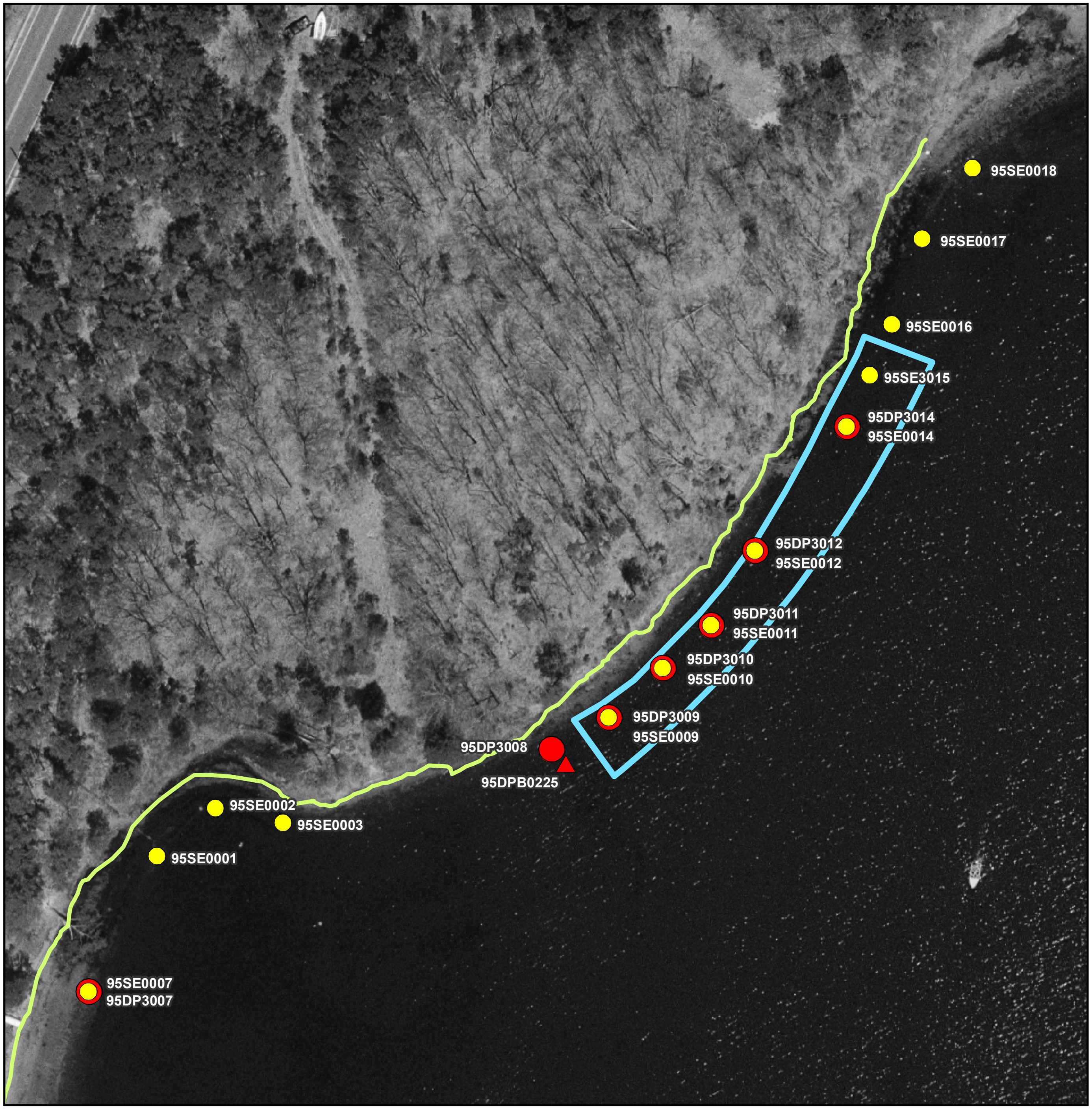

Legend

- Sediment Sample Location
- Drive Point Sample Location
- Co-located Sediment/Drive Point Sample
- 2005 Drive Point Sample Location
- Shoreline (Delineated by USGS July, 2006)
- *Barrier Boundary

**Barrier boundary delineated by ECC; shoreward edge refined based on GPS readings.*

N

0 40 80 Feet

Data Source: AFCEE, MMR-AFCEE Data Warehouse.
1997 Aerial Photography from AFCEE.

FIGURE 3-1

AFCEE TEMPORARY DRIVE POINT AND SEDIMENT SAMPLING LOCATIONS

AFCEE - Massachusetts Military Reservation
Final Ashumet Pond 2006 Phosphorus Barrier Technical Memorandum

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Table 3-1
2006 AFCEE Temporary Drive Point Barrier Groundwater Geochemistry Data
Final Ashumet Pond 2006 Phosphorus Barrier Technical Memorandum

Location	Sampling Date	Screen Interval (ft bpb)	Mid-Screen Depth (ft bpb)	pH (std)	Alkalinity (as $CaCO_3$) (mg/L)	Dissolved Barium (µg/L)	Dissolved Calcium (µg/L)	Chloride (mg/L)	Dissolved Iron (µg/L)	Dissolved Magnesium (µg/L)	Dissolved Manganese (µg/L)	Methane (µg/L)	Ammonium-N (mg/L)	Nitrate-N (mg/L)	Sulfate (mg/L)	Dissolved Sodium (µg/L)	Total Dissolved Phosphorus (mg/L)	Dissolved Orthophosphate (as P) (mg/L)
95DPB0225**	6/2/2005	1.0 to 2.0	1.5	6.14	45	12	11000	NS	36	5400	3100	0.57J	NS	NS	24	12000	0.970	NS
95DPB0225**	6/2/2005	3.5 to 4.5	4.0	6.20	48	13	11000	NS	21	5800	4200	0.74J	NS	NS	24	12000	1.000	NS
95DP3007*	10/3/2006	0.6 to 1.0	0.8	6.37	15J	30J	5800	7.1	ND	2100	35	ND	ND	2.33	14	8300	ND	NS
95DP3007*	10/3/2006	3.5 to 4.5	4.0	6.20	14J	35J	6000	7.4	ND	2100	29	ND	ND	2.38	13	8400	ND	ND
95DP3008*	10/3/2006	0.6 to 1.0	0.8	6.06	11J	34J	2900J	25	1400	2000J	2300	24	0.13	0.003J	7	12000	0.015	NS
95DP3008*	10/3/2006	3.5 to 4.5	4.0	5.99	25	41J	7500	28	ND	3900J	2100	0.37J	0.32	0.65	18	14000	0.034	0.0223J
95DP3009	10/4/2006	0.6 to 1.0	0.8	8.40	26	5.7J	3200J	26	ND	1700J	1000	130	0.31	0.0137	1.1	18000	0.052	NS
95DP3009	10/4/2006	3.5 to 4.5	4.0	7.04	14J	6.9J	3200J	23	410	1400J	2000	0.47J	0.16	0.615	10	16000	0.981	0.791J
95DP3010	10/4/2006	0.6 to 1.0	0.8	7.29	25	11J	4400J	26	830	2400J	1800	76	0.49	0.0063	7.1	17000	0.036	NS
95DP3010	10/4/2006	3.5 to 4.5	4.0	6.68	18J	4.2J	4800J	30	340	2600J	2000	0.2J	0.64	0.0022J	14	20000	1.802	1.616J
95DP3011	10/4/2006	0.6 to 1.0	0.8	6.63	66	35J	9900	25	32000	6100	4200	360	0.59	0.1921	ND	9500	0.004	NS
95DP3011	10/4/2006	3.5 to 4.5	4.0	6.77	45	12J	10000	20	1100	6300	3900	85	0.87	0.1486	20	9800	1.415	1.088J
95DP3012	10/4/2006	0.6 to 1.0	0.8	6.88	63	39J	11000	25	10000	6200	3500	610	0.63	ND	ND	12000	0.025	NS
95DP3012	10/5/2006	3.5 to 4.5	4.0	6.91	36	7.7J	9700	28	1100	5900	2400	9.9	0.73	ND	17	13000	1.507	0.827J
95DP3014	10/5/2006	0.6 to 1.0	0.8	6.55	8.5J	12J	9500	49	7300	3500J	1200	44	ND	ND	10	17000	0.022	NS
95DP3014	10/5/2006	3.5 to 4.5	4.0	6.42	ND	14J	9300	50	900	3700J	2100	0.35J	ND	0.534	14	19000	0.336	0.219J

Key:
ft bpb = feet below pond bottom
J = estimated data
mg/L= milligrams per liter
NS = not sampled
std = standard units
µg/L= micrograms per liter

** Background location 95DPB0225 sampled in June 2005

* Background locations 95DP3007 and 95DP3008 sampled in October 2006

Table 3-2
2006 AFCEE Barrier and Pond Surface Sediment Data
Final Ashumet Pond 2006 Phosphorus Barrier Technical Memorandum

Sediment Sampling Location	Sampling Date	Total Iron (mg/kg)	Total Phosphorus (mg/kg)	Total Manganese (mg/kg)
95SE0001	10/2/2006	4700	110	54
95SE0002	10/2/2006	1900	62	34
95SE0003	10/2/2006	1600	43	500J
95SE0007	10/2/2006	380	25J	70
95SE0009	10/5/2006	64000	NA	1500
95SE0010	10/5/2006	79000J	140J	1400
95SE0011	10/5/2006	74000	100	980
95SE0012	10/5/2006	23000	100	800
95SE0014	10/5/2006	66000	ND	700
95SE0015	10/5/2006	130000	140	1500
95SE0016	10/5/2006	18000	450	2000
95SE0017	10/5/2006	10000	330	700
95SE0018	10/5/2006	2100	48	400

Key:
J = estimated value
mg/kg = milligrams per kilograms
NA = Not Analyzed
ND = Non Detect